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The Economic Feasibility of Expanded Potato Processing in North Dakota

by
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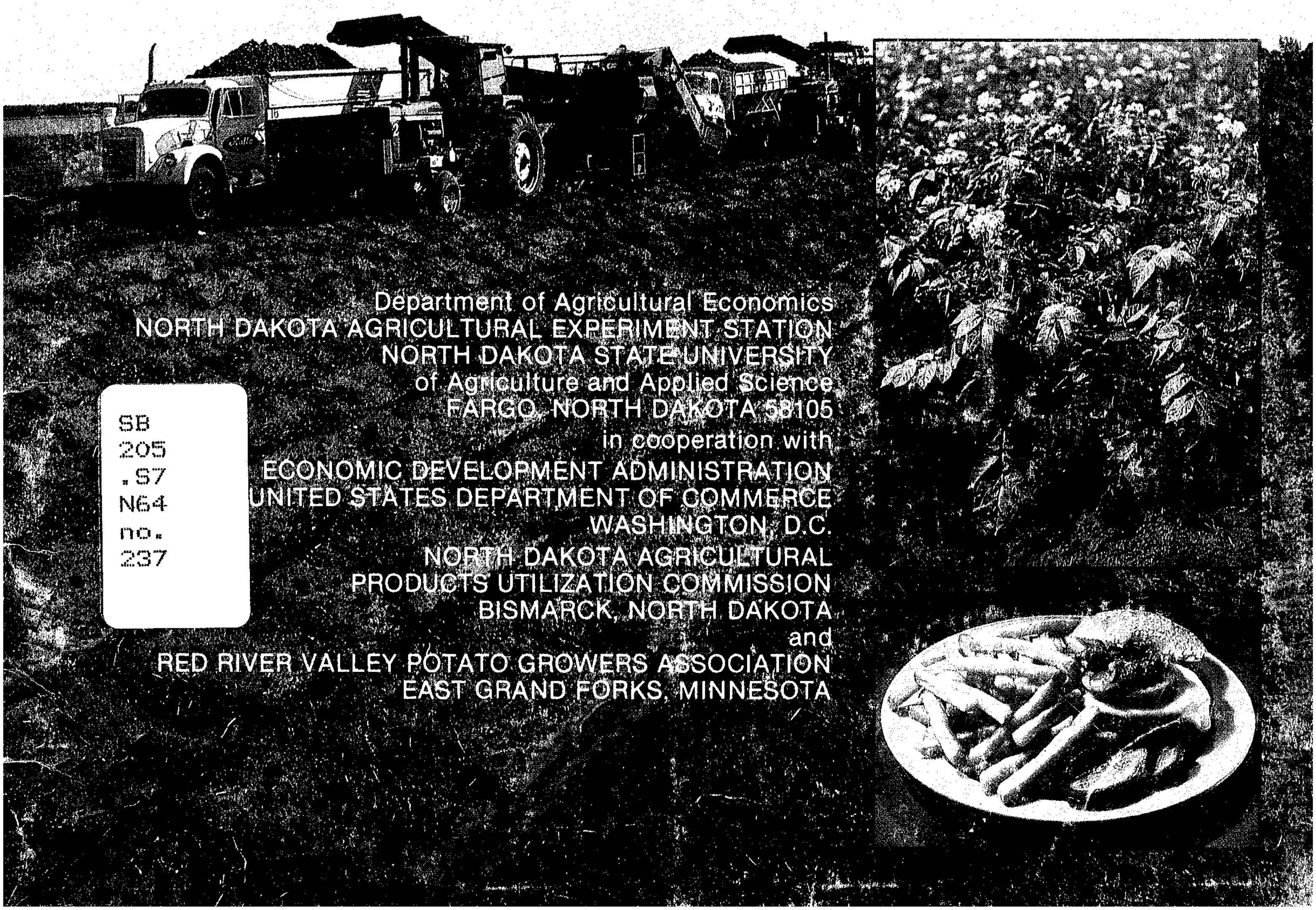

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Preface

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THE ECONOMIC FEASIBILITY OF EXPANDED POTATO PROCESSING IN NORTH DAKOTA

Scott M. Wulff and Delmer L. Helgeson[*]

Agricultural processing industries have been important for the state of North Dakota in maintaining and expanding the state's economic base. Oilseed processors, flour mills, pasta manufacturing, potato processors, meat packing, and sugar beet refining are important elements in North Dakota's economy.

Development of additional agricultural processing firms has been and is one of the more feasible and attractive means of providing new job opportunities. Processing agricultural products produced in the state is also highly complementary to agriculture, North Dakota's major industry. Additional processing firms mean expanded and/or new marketing alternatives for farmers.

This study investigates the economic feasibility of expanded potato processing in North Dakota. Emphasis was placed on analyzing market trends of various potato products to determine long-term market potential, cost analysis to determine profitability, and a transportation analysis to determine North Dakota's competitive position relative to existing and potential processing locations.

Data and other information in this report were collected from interviews with various trade and industry personnel, trade publications, research by various universities, and government sources.

Potato Production

U.S. potato production has been gradually increasing throughout the 1970s and 1980s. Production rose from 325 million cwt. in 1970 to 407 million cwt.in 1986. Annual production can vary greatly due to changes in planted acres and yields; however, the trend has been upward. This gradual upward trend is a result of increasing demand due to a growing population (Figure 1).

Seasonal Production

The greatest increases have been in the production of fall potatoes. Production of winter, spring, and summer potatoes has been decreasing. Production of winter, spring, and summer potatoes was 3.6, 25.3, and 43.3 million cwt. in 1970. By 1980 production was only 3.0, 19.8, and 20.9 million cwt. for winter, spring, and summer potatoes even though total potato production increased (Table 1). The increase in potato production comes exclusively from an increase in the production of fall potatoes.

Fall potato production accounted for 82.2 percent of total production in 1970. By 1986, this figure rose to 87.7 percent. The shift has been due primarily to the shift in demand from fresh to processed potatoes. Fall produced potatoes are better suited for processing and have a longer storage life. Fall potatoes are generally produced in more Northern states which have cooler climates that are more conducive to long-term storage.

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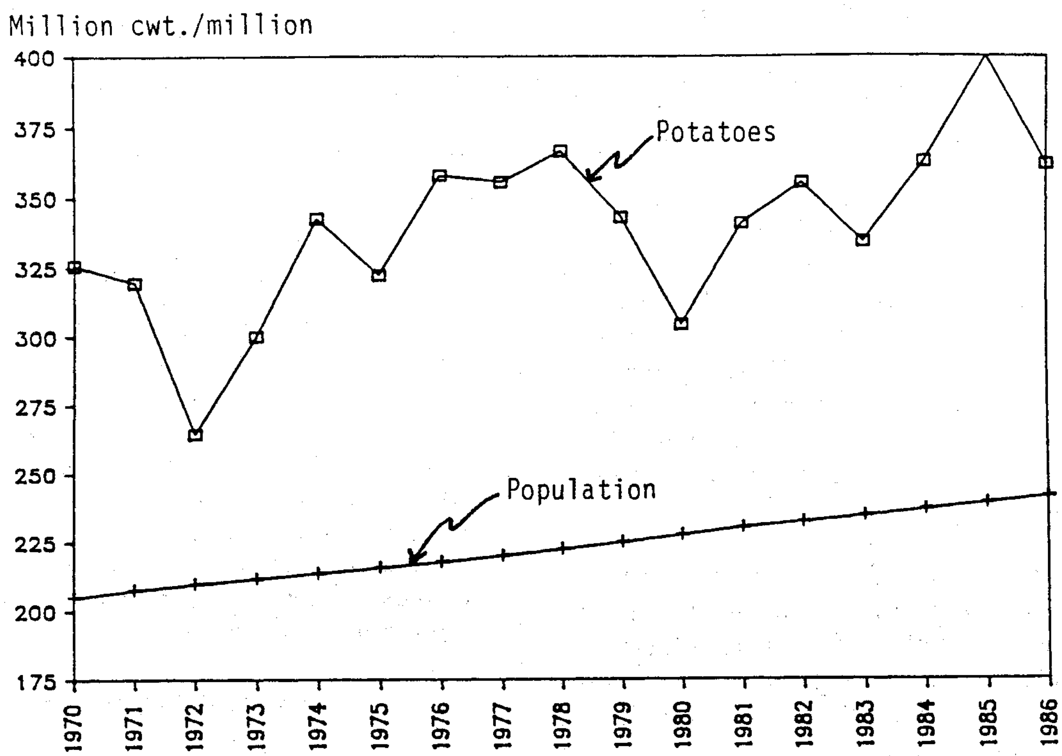

Figure 1. United States Potato Production and Population, 1970-1986

SOURCE: Bureau of the Census, 1987 and Economic Research Service, USDA, 1987.

TABLE 1. UNITED STATES POTATO PRODUCTION BY PRODUCTION SEASON, 1970-1986

Crop	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	million cwt.																
Winter	3.6	3.1	2.3	2.9	2.9	2.9	3.0	2.7	2.6	2.4	2.4	2.2	2.3	2.2	2.6	2.7	3.0
Spring	25.3	23.7	21.0	21.2	25.0	20.0	24.7	22.9	18.0	21.3	17.1	20.8	21.0	18.3	23.8	23.0	19.8
Summer	29.0	25.9	23.8	21.5	25.4	21.0	22.5	22.0	21.2	21.8	17.0	20.5	22.8	18.7	23.1	27.8	20.9
Fall	267.1	266.7	248.8	253.9	288.7	278.4	307.4	307.1	323.5	297.4	266.4	297.0	309.1	294.7	313.1	353.6	310.8
Total	324.9	319.4	296.0	299.4	342.1	322.3	357.7	354.6	365.2	342.9	302.9	340.6	355.1	333.9	362.6	407.1	354.5

SOURCE: Agricultural Statistics, Various Issues.

Currently, the market share of winter potatoes is less than 1 percent, spring potatoes less than 6 percent, and summer potatoes less than 7 percent (Table 2). Winter, spring, and summer potatoes are generally merchandized through either the tablestock or chipping markets. Most of the nonfall producing states are in warmer climates which are not conducive to long-term storage.

Winter potatoes are primarily produced in California and Florida. Production is generally between 3.6 and 2.2 million cwt. annually. Production of spring potatoes is generally between 18 and 25 million cwt. Primary producer states are California, Florida, Arizona, and Texas. Production of summer potatoes varies between 17.0 and 30.4 million cwt. annually. Primary producer states are Colorado, Texas, New Jersey, Michigan, Minnesota, Delaware, and Virginia (Table 3).

The production of fall potatoes has seen tremendous growth since 1970. Production has increased from 252 million cwt. in 1970 to over 350 million cwt. in 1986. Primary production states are Idaho, Oregon, Washington, Maine, Michigan, Minnesota, North Dakota, Wisconsin, and Colorado. Numerous other states produce lesser amounts. All of the primary states except Maine have increased production. The greatest increases have been in Idaho, Washington, and Oregon. Idaho increased from 74.7 to 87.3 million cwt. between 1970 and 1986. Washington increased from 34 to 60.2 million cwt., and Oregon increased from 15.4 to 23.2 million cwt. Colorado has also expanded production significantly in the last four years, increasing from 11.6 million cwt. in 1981 to over 18.2 million cwt. in 1986. None of the lesser states have had significant increases in production (Table 4).

TABLE 2. POTATOES: SEASONAL MARKET SHARE, UNITED STATES, 1970-1986

Crop	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
									percent								
Winter	1.1	1.0	.8	1.0	.9	.9	.8	.8	.7	.7	.8	.6	.6	.7	.7	.7	.8
Spring	7.8	7.4	7.1	7.1	7.3	6.2	6.9	6.4	4.9	6.2	5.6	6.1	5.9	5.5	6.6	5.6	5.6
Summer	8.9	8.1	8.0	7.2	7.4	6.5	6.3	6.2	5.8	6.4	5.6	6.0	6.4	5.6	6.4	6.8	5.9
Fall	82.2	83.5	84.1	84.8	84.4	86.4	86.0	86.6	88.6	86.7	88.0	87.2	87.0	88.3	86.3	86.9	87.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: Adapted from Table 1.

TABLE 3. UNITED STATES WINTER, SPRING, AND SUMMER POTATO PRODUCTION, BY STATE 1970-1986

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	million cwt.																
Winter																	
Florida	1.6	1.5	1.4	1.8	1.8	1.8	1.8	1.6	1.9	1.6	1.7	1.3	1.3	.9	1.2	1.3	1.5
California	2.0	1.6	1.0	1.1	1.2	1.1	1.1	1.1	.7	.8	.7	.9	.9	1.3	1.5	1.4	1.5
Total	3.6	3.1	2.3	2.9	2.9	2.9	3.0	2.7	2.6	2.4	2.4	2.2	2.3	2.2	2.6	2.7	3.0
Spring																	
N. Carolina	1.8	1.7	1.6	1.6	2.1	1.9	1.9	2.2	2.0	2.3	1.8	2.1	2.4	2.0	2.4	2.3	2.1
Florida																	
Hasting Co.	4.0	3.0	3.0	3.4	3.3	3.2	4.1	4.3	3.5	4.3	3.5	5.0	5.4	4.9	6.5	6.4	6.9
Other	.3	.3	.3	.3	.5	.4	.4	.3	.2	.2	.1	.2	.3	.2	.2	.3	.2
Alabama	1.0	1.0	1.4	1.3	1.8	1.4	1.6	1.3	1.0	1.0	.6	.7	.7	.5	.6	.8	.7
Mississippi	.2	.2	.2	.2	.2	.1	.1	.1	.1	—	—	—	—	—	—	—	—
Arkansas	.1	.1	.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana	.2	.2	.2	.2	.3	.2	.2	.2	.2	.2	.1	.1	.1	.1	.1	.0	.0
Texas	.4	.9	.8	.8	1.0	.8	1.1	.9	1.2	1.1	.8	.8	1.1	1.1	1.2	1.1	1.1
Arizona	2.7	2.8	2.4	2.1	2.2	1.5	1.8	1.8	1.6	1.3	1.3	1.5	1.4	1.3	1.6	1.5	1.3
California	14.5	13.4	11.1	11.3	13.7	10.5	13.5	11.9	8.3	11.1	8.8	10.3	9.6	8.3	11.1	10.6	7.6
Total	25.3	23.7	21.0	21.2	25.0	20.0	24.7	22.9	18.0	21.3	17.1	20.8	21.0	18.3	23.8	23.0	19.8
Summer																	
New Jersey	3.2	3.0	2.1	1.7	2.4	1.4	2.0	2.1	2.1	2.1	2.0	2.1	2.2	1.6	1.8	2.5	1.9
Ohio	.7	.6	.5	.4	.6	.3	.4	.3	.3	.3	.3	.2	.3	.2	.3	.3	.0
Indiana	.2	.2	.1	.1	.2	.3	.4	.4	.3	.3	.2	.3	.4	.2	.2	.3	.0
Illinois	.3	.3	.4	.3	.2	.5	.5	.5	.4	.5	.4	.5	.6	.6	.6	.9	.8
Michigan	2.3	1.3	1.8	1.1	1.6	1.4	1.3	1.4	1.5	1.5	1.6	2.0	2.3	2.2	2.6	3.0	1.8
Minnesota	3.7	1.9	1.8	1.9	2.1	2.1	2.0	2.1	2.0	1.8	1.6	1.6	1.9	1.3	1.7	1.8	1.6
Iowa	.6	.7	.7	.5	.7	.5	.5	.5	.3	.2	.3	.3	.3	.2	.2	.3	.3
Missouri	.1	.1	.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska	.4	.4	.4	.4	.4	.4	.4	.3	.3	.3	.3	.2	.2	.2	.6	.7	.6
Kansas	.1	.1	.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Delaware	1.5	1.4	1.2	1.3	1.5	1.1	1.2	1.1	1.1	1.2	1.0	1.2	1.6	1.0	1.3	1.8	1.3
Maryland	.3	.4	.4	.3	.3	.3	.3	.2	.2	.3	.3	.3	.4	.3	.3	.3	.3
Virginia	4.0	4.3	4.1	.3	.3	.2	.2	.2	3.0	2.6	1.5	2.3	2.5	1.0	1.5	3.3	1.1
W. Virginia	.3	.3	.3	3.3	4.0	2.4	3.5	3.5	—	—	—	—	—	—	—	—	—
N. Carolina	.2	.3	.4	.4	.6	.5	.5	.5	.5	.5	.4	.5	.4	.4	.3	.3	.2
Kentucky	.2	.2	.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee	.4	.4	.4	.3	.5	.4	.4	.4	.4	.3	.2	.3	.3	.2	.3	.4	.2
Alabama	1.1	.8	1.0	1.0	1.5	1.4	1.2	.8	1.2	1.5	.5	1.4	1.3	1.0	1.0	1.4	1.0
Texas	3.6	2.4	2.4	2.9	2.2	2.2	2.4	2.4	2.3	2.6	1.5	1.5	2.1	2.2	2.8	2.8	2.5
Colorado	3.2	3.0	2.1	1.4	1.8	1.9	2.0	1.8	1.7	1.9	1.6	1.9	1.8	1.9	2.0	2.2	2.1
New Mexico	.6	.5	.9	.8	.8	.7	.6	.6	.8	1.2	.5	.9	1.3	1.6	2.6	2.9	2.7
California	2.1	3.5	2.6	3.0	3.5	3.1	2.9	3.0	2.8	2.7	2.8	3.0	3.1	2.6	2.9	2.7	2.3
Total	29.0	25.9	23.8	21.5	25.4	21.0	22.5	22.0	21.2	21.8	17.0	20.5	22.8	18.7	23.1	27.8	20.9

SOURCE: Agricultural Statistics, Various Issues.

TABLE 4. FALL POTATO PRODUCTION BY STATE, 1970-1986

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	million cwt.																
Fall																	
Maine	35.7	37.7	33.3	28.8	36.4	26.8	27.4	28.3	26.0	27.7	25.0	26.5	27.0	22.6	21.4	28.2	21.0
N. Hampshire	.2	.2	.2	.1	.1	.1	.1	.1	--	--	--	--	--	--	--	--	--
New York																	
Long Island	7.3	7.2	5.6	5.4	6.8	6.1	7.4	7.2	6.2	6.4	4.8	5.4	5.1	4.1	3.6	3.9	2.5
Upstate	9.7	7.9	5.0	6.7	7.0	6.1	6.1	5.4	6.5	6.5	6.3	6.9	6.5	5.6	6.6	6.4	5.3
Vermont	.2	.3	.2	.2	.2	.2	.2	.2	.2	.1	.1	.1	.1	.1	.1	.0	.0
Massachusetts	1.0	1.0	.6	.6	.8	.8	.8	.9	.8	.7	.7	.7	.8	.6	.6	.8	.7
Rhode Island	1.3	1.2	.9	.8	1.0	1.0	1.1	.9	1.0	.8	.7	.8	.7	.6	.6	.7	.4
Connecticut	1.1	.9	.6	.6	.6	.6	.5	.5	.4	.5	.4	.5	.4	.3	.3	.4	.2
Pennsylvania	8.3	7.8	5.1	6.3	7.4	6.8	7.1	6.4	6.3	6.0	4.2	5.3	4.9	4.3	5.2	5.7	5.2
Ohio	2.5	2.5	2.0	1.8	2.1	2.6	2.9	2.7	2.2	2.4	2.0	1.9	2.2	1.9	2.4	2.5	2.4
Indiana	1.6	1.7	1.2	1.2	1.2	1.4	1.5	1.1	.9	1.1	.7	.6	.9	.6	.8	.6	1.0
Michigan	7.6	8.2	7.9	7.5	8.3	6.7	8.3	8.8	8.5	8.0	7.4	8.6	10.5	9.8	12.5	12.1	9.4
Wisconsin	13.0	13.2	11.5	11.5	14.0	14.9	15.4	18.0	17.3	17.0	16.0	18.2	22.6	18.9	21.4	24.1	20.1
Minnesota	11.4	14.9	13.3	13.1	15.3	9.7	11.1	13.0	14.9	12.9	9.9	13.3	11.5	10.3	13.8	14.1	13.7
North Dakota	17.4	20.0	17.4	19.1	23.0	17.6	16.9	21.6	22.4	18.2	15.7	20.1	17.3	20.5	20.6	23.6	21.6
South Dakota	.7	1.1	.7	.8	.4	.6	.3	1.1	1.2	1.2	1.1	.7	1.6	2.3	1.8	2.1	2.3
Nebraska	1.7	1.1	1.0	1.0	1.2	1.2	1.3	1.4	1.8	1.5	1.9	2.3	2.3	2.0	2.5	2.1	1.8
Montana	1.4	1.4	1.7	1.5	1.8	1.7	1.8	2.0	2.1	1.8	1.7	1.7	1.9	1.8	1.9	1.9	2.2
Idaho																	
10 SE Co.	10.2	9.6	9.0	11.5	11.5	10.6	11.4	9.0	10.4	10.5	7.8	8.0	8.6	8.5	9.4	10.9	6.1
Other Co.	64.5	67.7	68.3	67.4	69.7	67.9	77.1	79.2	89.9	75.0	72.0	76.4	83.2	77.5	77.2	91.6	81.2
Wyoming	.6	.9	1.3	1.2	1.5	1.6	1.7	1.5	1.5	1.1	1.3	1.1	1.1	.7	.6	.2	.5
Colorado	10.0	7.6	7.9	8.2	8.8	8.6	9.3	9.5	11.3	11.5	11.0	11.6	12.8	14.0	17.2	17.9	18.2
Utah	1.1	.8	1.0	1.1	1.5	1.5	1.2	1.4	1.1	1.4	1.2	1.3	1.4	1.4	1.7	1.7	1.8
Washington	33.6	30.1	31.4	35.3	41.2	48.3	55.8	50.6	50.7	48.5	43.9	52.9	52.8	54.1	56.9	63.6	60.2
Oregon																	
Malheur Co.	5.8	5.5	4.0	5.0	3.9	3.6	4.1	3.6	3.8	4.8	3.7	3.5	3.9	3.3	4.0	3.7	2.4
Other Co.	9.6	8.3	10.5	10.9	13.6	20.8	24.8	22.0	24.7	20.5	16.1	18.3	17.2	17.4	19.6	23.1	20.8
California	9.5	8.1	7.4	6.3	6.4	6.4	6.5	6.0	6.1	6.4	6.4	6.9	7.6	7.8	7.3	8.4	7.1
Nevada	--	--	--	--	3.2	4.1	5.3	4.8	5.4	5.0	4.4	3.5	4.1	3.7	3.3	3.1	2.8
Total	252.8	266.7	248.8	253.9	288.7	278.4	307.4	307.1	323.5	297.4	266.4	297.0	309.1	294.7	313.1	353.6	310.8

SOURCE: Agricultural Statistics, Various Issues.

Twelve states, California, Colorado, Florida, Idaho, Maine, Michigan, Minnesota, North Dakota, Oregon, New York, Washington, and Wisconsin, have accounted for over 85 percent of the total U.S. potato production since 1970. Significant shifts in production have occurred between these states. The Pacific Northwest (PNW) states, Idaho, Oregon and Washington, have increased their market share from 39 percent in 1970 to over 48 percent by 1976. The Pacific Northwest has maintained their market share since. Washington is the primary state gaining additional market share increasing from 10 percent of the fall total in 1970 to 17 percent in 1986. Colorado and Wisconsin have increased their market share modestly. Maine, New York, and California have been the primary losers. North Dakota has maintained its market share between 5 and 6 percent of total U.S. production while Minnesota has decreased slightly from about 5 percent in the early 1970s to approximately 4 to 4.5 percent in the 1980s (Table 5). The major potato production areas are graphically presented in Figure 2. The graph indicates that, in general, major production areas are defined within state boundaries. The exception is that Minnesota and North Dakota have a common production area, the Red River Valley.

Productivity

The primary contributing factor for production increases in both U.S. and individual state production is a significant increase in yields rather than acreage increases (Figure 3). Only Washington, Wisconsin, and Colorado have increased their acreage since 1970.

Washington has the highest yields exceeding 500 cwt./acre in 1985 and 1986. Following Washington are Oregon, California, Wisconsin, and Idaho. Overall, the U.S. average yield increased from 229 cwt./acre in 1970 to 292 cwt./acre in 1986 (Table 6 and Figures 4-6).

All primary production states except Maine have statistically increased their yields from 1970 to 1986. Trend analysis for Washington, Wisconsin, New York, Florida, and Oregon yields indicate that the rate of increase is slowing down, suggesting that future increases in yield will come more slowly (Table 7).

During the 1970 to 1986 period Washington had the highest annual yield increase at 6.85 cwt./acre followed by Wisconsin, Oregon, and Colorado. North Dakota has the lowest annual yield increase at 1.09 cwt./year (Table 7). The rapid increase in yields for most states excluding North Dakota and Maine is the increased use of irrigation. The combination of no productivity increase in Maine coupled with significant yield increases in the Western states have contributed to a shift in production from Maine to the Western states.

Regional Prices

High production efficiency in the Pacific Northwest (PNW) has been cited as one of the factors in the development of the processed potato industry in that region (Buteau 1986). Low production costs in the PNW are generally attributed to efficiencies gained from higher yields. Higher yields result in lower costs, primarily lower seed and harvesting costs.

In the early 1970s lower production costs resulted in increased production and lower prices for PNW states. For example, in 1970, 1971, 1972, and 1973 Washington potato prices were \$.70, \$.37, \$.88, and \$1.75/cwt.. lower than the U.S. fall potato average (Table 8). However, by 1984 the price benefit enjoyed by Washington processors had narrowed considerably (Figure 7).

TABLE 5. POTATO PRODUCTION MARKET SHARE, PRINCIPAL STATES, 1970-1986

State	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	percent																
Idaho	22.9	24.2	26.1	26.4	23.7	24.4	24.7	24.9	27.5	25.0	26.4	24.8	25.8	25.8	23.9	25.2	24.6
Oregon	4.7	4.3	4.9	5.3	5.1	7.6	8.1	7.2	7.8	7.4	6.5	6.4	5.9	6.2	6.5	6.6	6.5
Washington	10.3	9.4	10.6	11.8	12.0	15.0	15.6	14.3	13.9	14.1	14.5	15.5	14.9	16.2	15.7	15.6	17.0
California	8.6	8.3	7.4	7.2	7.2	6.5	6.7	6.2	4.9	6.1	6.2	6.2	6.0	6.0	6.3	5.7	5.2
Colorado	4.0	3.3	3.4	3.2	3.1	3.3	3.1	3.2	3.6	3.9	4.1	4.0	4.1	4.7	5.3	4.9	5.7
Florida	1.8	1.5	1.6	1.8	1.6	1.7	1.8	1.8	1.5	1.8	1.8	1.9	2.0	1.8	2.2	1.9	2.4
Maine	11.0	11.8	11.2	9.6	10.6	8.3	7.7	8.0	7.1	8.1	8.2	7.8	7.6	6.8	5.9	6.9	5.9
Michigan	3.0	3.0	3.3	2.9	2.9	2.5	2.7	2.9	2.7	2.8	3.0	3.1	3.6	3.6	4.2	3.7	3.2
Minnesota	4.7	5.2	5.1	5.0	5.1	3.7	3.6	4.2	4.6	4.3	3.8	4.4	3.8	3.5	4.3	3.9	4.3
North Dakota	5.3	6.3	5.9	6.4	6.7	5.5	4.7	6.1	6.1	5.3	5.2	5.9	4.9	6.1	5.7	5.8	6.1
New York	5.2	4.8	3.6	4.0	4.0	3.8	3.8	3.5	3.5	3.8	3.6	3.6	3.3	2.9	2.8	2.5	2.2
Wisconsin	4.0	4.1	3.9	3.8	4.1	4.6	4.3	5.1	4.7	5.0	5.3	5.3	6.4	5.7	5.9	5.9	5.7
Total	85.7	86.2	86.9	87.5	86.3	86.7	86.9	87.3	87.9	87.5	88.6	88.9	88.2	89.2	88.5	88.8	88.9

SOURCE: Adapted from Table 3 and 4.

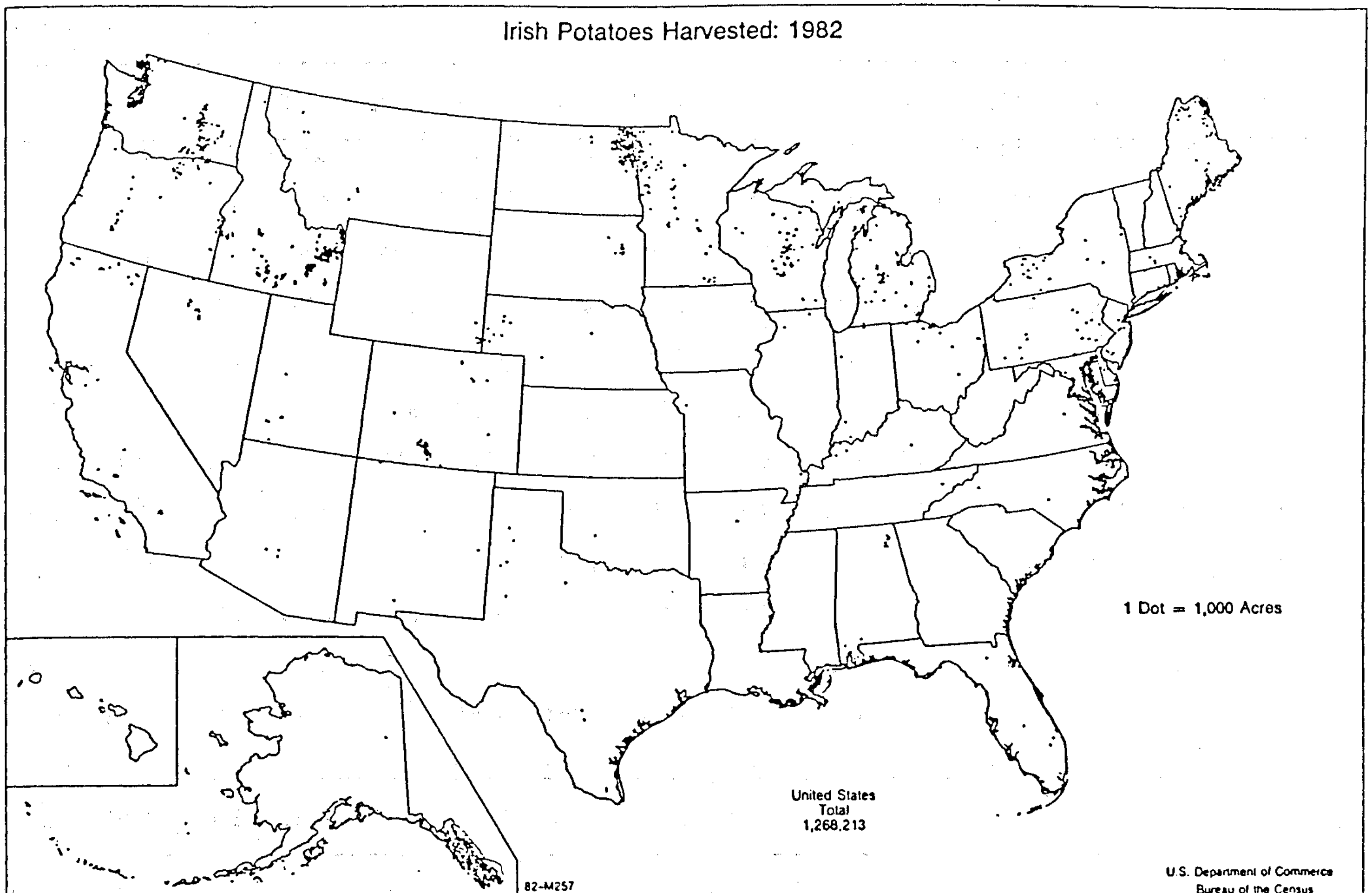

Figure 2. Geographic Distribution of United States Potato Acreage, 1982

SOURCE: 1982 Census of Agriculture.

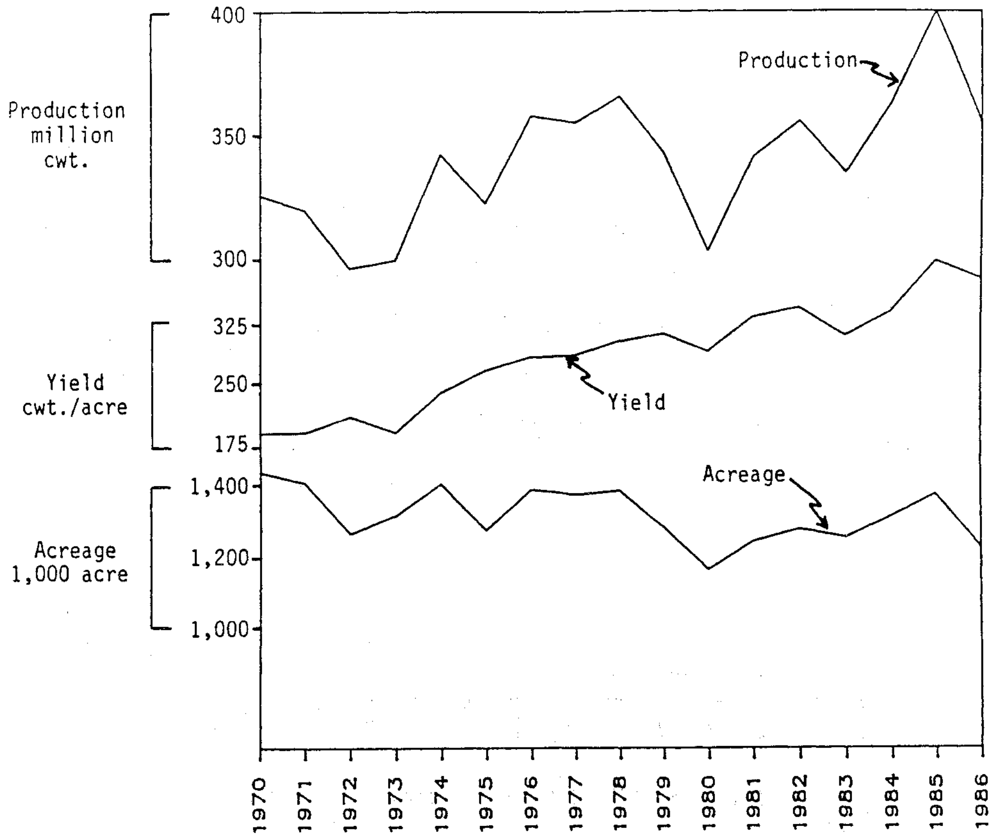

Figure 3. Potato Acreage, Production, and Yield, United States, 1970-1986

SOURCE: Agricultural Statistics, 1987.

TABLE 6. YIELDS PER ACRE, POTATOES BY PRINCIPAL STATES, 1970-1986

State	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	cwt./acre																
Idaho	228	242	258	244	237	244	244	245	275	259	266	266	285	276	266	297	284
Washington	386	386	418	430	420	460	450	460	465	475	505	490	480	520	495	505	510
Oregon	281	289	355	380	350	440	441	426	421	402	420	402	402	427	416	440	446
Maine	238	260	260	210	260	220	245	240	220	245	240	255	255	240	240	285	250
Colorado	256	244	259	261	262	264	257	261	272	288	297	289	282	297	320	318	325
Michigan	246	211	239	216	234	222	231	257	235	235	227	235	260	228	266	262	266
Minnesota	158	172	177	167	186	181	174	189	216	198	166	196	190	172	197	211	201
North Dakota	150	155	145	145	170	160	140	160	175	160	140	175	150	160	155	170	180
Wisconsin	251	256	253	245	280	300	290	328	315	315	320	340	350	305	350	380	350
New York	264	230	201	223	255	257	277	289	262	285	252	281	264	238	262	267	248

SOURCE: Agricultural Statistics, Various Issues.

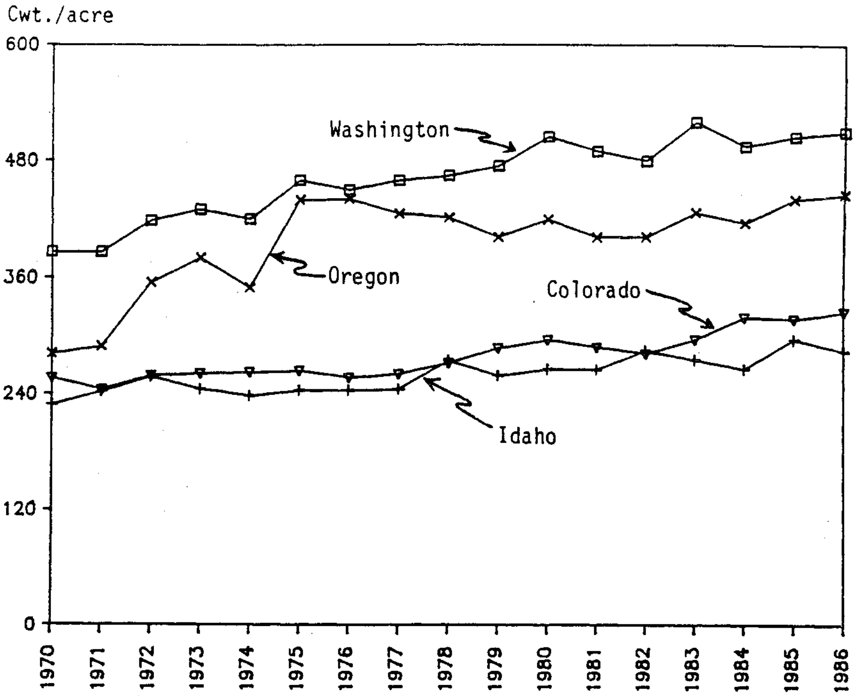

Figure 4. Potato Yields, Colorado, Idaho, Oregon, Washington, 1970-1986

SOURCE: Agricultural Statistics, 1987.

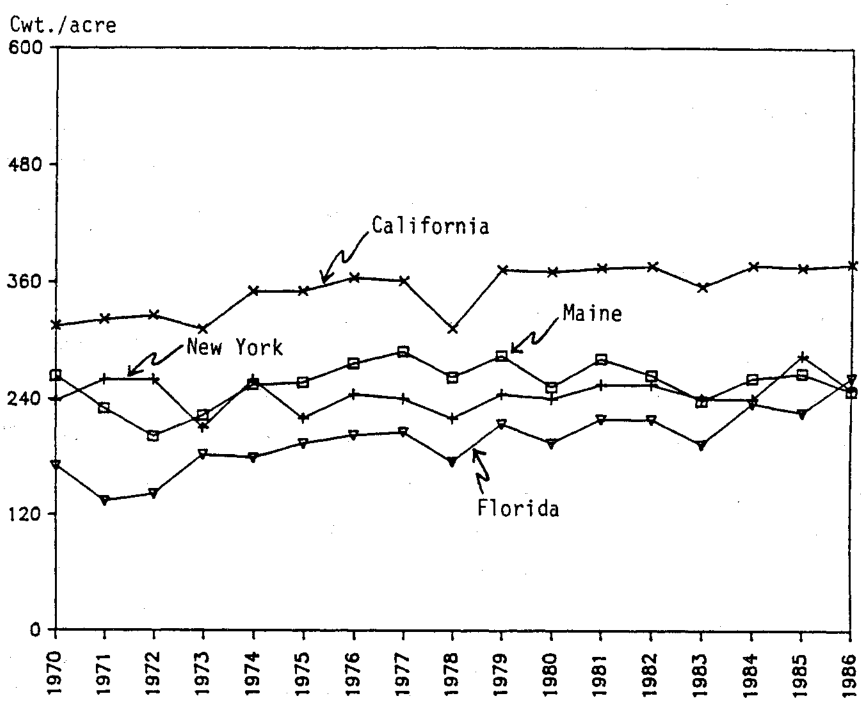

Figure 5. Potato Yields, California, Florida, Maine, New York, 1970-1986

SOURCE: Agricultural Statistics, 1987.

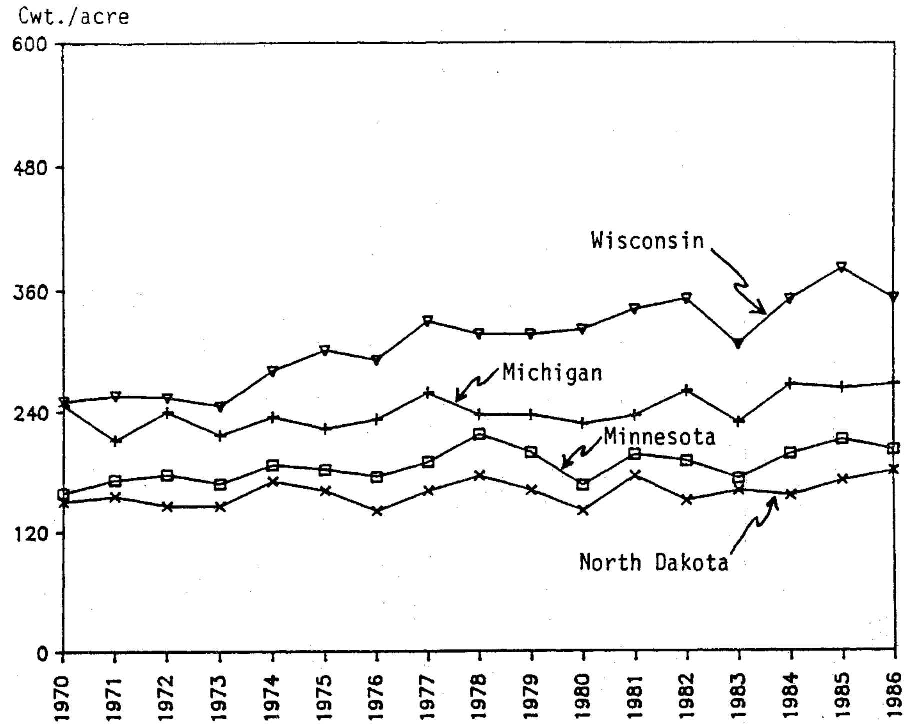

Figure 6. Potato Yields, Michigan, Minnesota, North Dakota, Wisconsin, 1970-1986

SOURCE: Agricultural Statistics, 1987.

TABLE 7. ESTIMATED AVERAGE, ANNUAL YIELD INCREASES, POTATOES, PRINCIPAL STATES, 1970-1986

State	Cwt./Acre	Is Rate of Yield Increases Slowing?
California	3.44	Yes
Colorado	4.58	No
Florida	4.62	Yes
Idaho	3.32	No
Maine	No Change	NA
Michigan	2.07	Yes
Minnesota	1.67	Yes
New York	2.02	No
North Dakota	1.09	No
Oregon	5.04	Yes
Washington	6.85	Yes
Wisconsin	5.60	Yes
United States	3.46	Yes

SOURCE: Based on Regression Analysis of Secondary USDA Yield Data, 1970-1986.

TABLE 8. FALL POTATO PRICES, UNITED STATES AND PRINCIPAL STATES, 1970-1986

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	cwt./acre																
Maine	1.98	1.70	4.10	7.25	2.90	6.05	4.95	3.36	3.86	3.25	7.25	4.50	3.35	6.25	4.30	2.80	5.00
Michigan	2.69	2.39	3.85	6.15	4.10	5.60	4.20	4.13	4.53	4.45	6.60	6.15	4.70	6.60	5.50	4.45	5.80
Wisconsin	2.52	2.13	3.57	6.40	3.65	5.40	3.95	3.95	4.13	4.30	10.10	4.70	4.10	5.55	4.80	3.15	4.70
Minnesota	1.58	1.30	2.80	3.95	3.05	4.20	3.25	2.74	2.71	3.05	7.70	4.55	3.80	5.20	4.70	2.95	6.10
North Dakota	1.67	1.23	2.75	4.60	3.15	4.20	3.45	2.70	2.60	3.25	6.85	4.05	4.35	4.90	4.65	3.20	4.15
Idaho	1.80	1.67	2.45	3.85	3.80	3.75	2.95	2.95	2.25	2.95	5.65	4.75	3.50	5.20	4.85	3.30	4.35
Colorado	1.25	1.44	3.05	5.45	2.40	3.95	2.55	2.80	2.15	2.90	7.05	4.60	3.50	6.40	4.65	2.25	3.60
Washington	1.37	1.40	2.09	2.90	3.65	3.15	2.50	2.80	2.45	2.55	4.40	3.95	3.75	4.25	5.15	3.45	4.20
Oregon	1.78	1.73	2.75	3.86	3.88	3.19	2.71	2.88	2.76	2.83	4.60	4.48	3.90	4.64	4.77	3.56	4.43
United States	2.07	1.77	2.97	4.65	3.60	4.25	3.33	3.19	2.93	3.24	6.36	4.74	3.92	5.46	5.03	3.42	4.60

SOURCE: Agricultural Statistics, Various Issues.

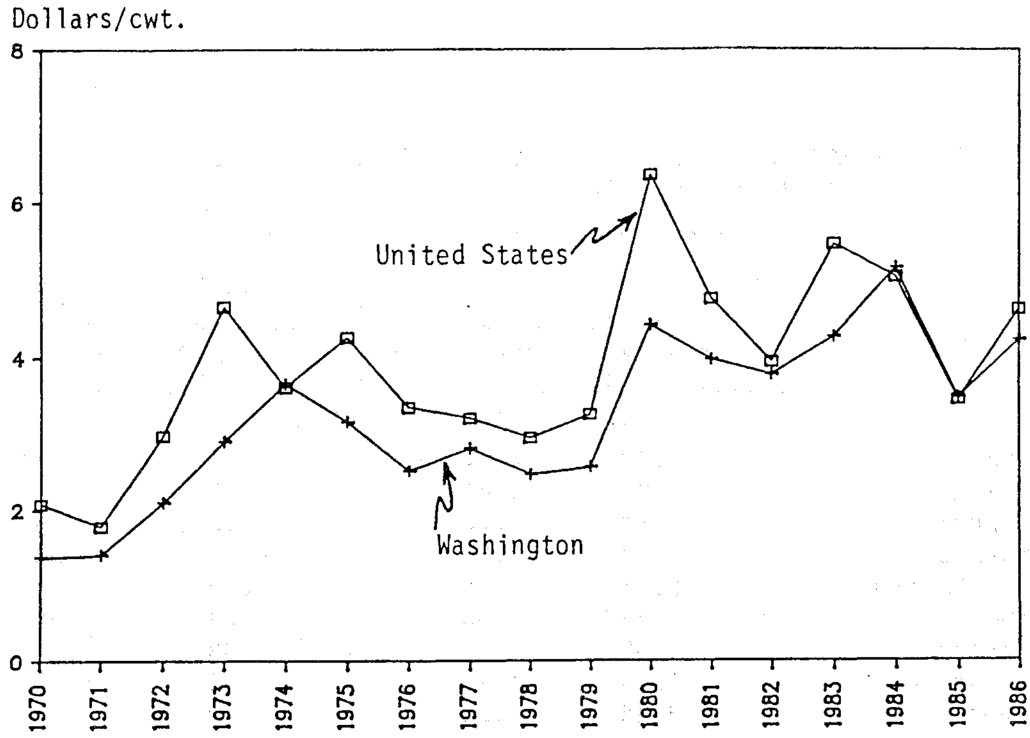

Figure 7. United States and Washington State Fall Potato Price

SOURCE: Agricultural Statistics, 1987.

It appears that potato prices are becoming more uniform as time progresses. Comparing a recent 5-year (1982-1986) state average price to a longer 17-year (1970-1986) average there was less deviation from the U.S. average (Table 9). Idaho's recent 5-year (1982-1986) average was $.23/cwt. lower than the U.S. average compared to $.40/cwt. for the entire time period. Washington likewise deviated $.33/cwt. during 1982-86 compared to $.68/cwt. during 1970-86. Wisconsin and Maine potato prices have also come closer to the U.S. average. Michigan remains above the U.S. average with no change. North Dakota remains slightly below the national average for fall potatoes.

Utilization

There are six major utilization categories for potatoes. These are tablestock (fresh), processed, seed, feed, government diversion, and shrinkage and loss. Processed potatoes include frozen french fries, other frozen products, chips, dehydrated products, canned, starch, and flour.

Tablestock usage has fluctuated between 129.5 million cwt. and 96.8 million cwt. between 1970 and 1986. No annual trend is obvious as population increases have offset declines in per capita consumption. Processed potato products have seen tremendous growth from 136.6 million cwt. in 1970 to over 192 million cwt. by 1985. This increase is a result of both per capita consumption and population increases and to a lesser extent increased exports of frozen products. Not all processed products have participated in this growth. The primary gainers have been frozen french fries, increasing from 54.5 million cwt. in 1970 to 96.2 million cwt. in 1986. Other frozen potato products have increased from 7.4 million cwt. in 1975 to 15.7 million cwt. in 1986. Dehydrated product use increased from 1970 to 1976 when use peaked at 40.4 million cwt.;

TABLE 9. AVERAGE FALL POTATO PRICES AND PRICE DIFFERENTIALS BY STATE, 1970-1986 AND 1982-1986

State	Average Price		Price Differentials From U.S. Average	
	1970-1986	1982-1986	1970-1980	1982-1986
	$/cwt			
Maine	4.29	4.34	.43	-.15
Michigan	4.82	5.41	.96	.92
Wisconsin	4.54	4.46	.68	-.03
Minnesota	3.74	4.55	-.11	.06
North Dakota	3.63	4.25	-.22	-.24
Idaho	3.53	4.24	-.32	-.25
Colorado	3.53	4.08	-.33	-.41
Washington	3.18	4.16	-.68	-.33
Oregon	3.46	4.26	-.40	-.23
United States	3.85	4.49	.00	.00

SOURCE: Adapted from Table 8.

however, dehydrated use has since dropped below 30 million cwt. for the previous seven years. This decrease occurred despite a growing population base. Canned potato use has remained relatively constant between 4 to 4.6 million cwt. for most of the period. Starch and flour consumption has also been minimal with the annual usage between 2.2 and 4.6 million cwt. (Table 10).

For all categories of potato products there exists significant year-to-year changes due to fluctuations in annual production and consumption. During a low production year all products experience a decline in usage as higher prices discourage consumption. An example year would be 1980. Likewise, utilization increases during periods of high production as low prices encourage consumption.

Seed use remained relatively constant accounting for approximately 25 million cwt. annually. Feed use varies between 3.8 and 11.1 million cwt. and is highly dependent on price and quality of potatoes. During periods of low prices, as in 1980, feed usage increased dramatically.

Government diversion programs removed 12 and .5 million cwt. from the market in 1978 and 1979. Shrinkage, waste, and loss account for 23.8 to 52.8 million cwt. annually. Shrinkage and loss is also dependent on annual production and quality.

From 1980 to 1986 nonfood use accounted for 17.7 percent of total annual production. Shrinkage accounted for 8.9 percent; feed, 1.7 percent; and seed, 7.2 percent of annual production. Nonfood usage is fairly constant as a percentage of annual production except for extremely high product years as 1985 (Table 11).

Domestic Potato Consumption

Domestic per capita potato consumption has remained relatively constant since 1970. Consumption has ranged between

TABLE 10. UTILIZATION OF THE UNITED STATES POTATO CROP, 1970–1986

Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	million cwt.																
Table stock	129.5	120.3	111.7	107.6	125.7	114.2	123.1	116.6	111.1	115.0	96.8	112.0	120.3	107.3	113.7	125.3	109.7
Processing:																	
Chips	35.9	35.4	34.6	34.5	32.8	34.1	34.6	36.9	37.8	38.3	37.9	39.3	40.7	43.3	42.6	42.2	45.4
Dehydration	26.1	27.0	27.5	31.4	34.7	33.8	40.4	32.8	33.2	30.8	28.2	29.9	27.7	26.8	27.8	30.0	28.4
Frozen french fries	54.5	54.7	56.1	60.3	69.2	70.6	79.7	79.9	79.5	74.3	67.2	79.8	76.1	74.4	86.0	94.7	96.2
Other frozen prod.	7.4	8.9	7.9	9.6	9.2	9.3	12.9	14.6	15.4	14.4	13.7	16.8	17.3	19.7	21.5	17.9	15.7
Canned potatoes	2.4	2.6	2.1	2.7	2.6	1.9	1.9	2.8	2.7	2.5	2.1	2.5	2.7	2.1	2.6	3.0	4.2
Other canned prod.	1.9	2.0	2.2	2.5	2.1	2.1	2.6	2.5	2.1	2.3	2.0	1.7	1.8	2.0	1.8	1.6	—
Starch & flour	8.6	7.8	3.4	2.7	3.7	2.2	2.8	2.4	3.5	3.6	2.2	2.3	4.6	3.0	3.4	3.5	2.8
Total	36.6	138.3	133.8	143.7	154.2	154.1	174.7	171.9	174.3	166.1	153.2	172.3	170.9	171.2	185.7	192.8	192.7
Seed	24.5	22.3	23.6	25.3	23.8	25.6	25.6	25.9	24.7	22.3	24.1	24.9	24.2	25.5	27.1	25.1	25.5
Feed	8.3	7.2	5.0	3.7	4.2	4.3	6.3	7.4	7.2	6.6	3.9	3.6	6.2	3.8	6.0	11.1	5.2
Diversion	.0	.0	.0	.0	.0	.0	.0	.0	12.0	.5	.0	.0	.0	.0	.0	.0	.0
Shrinkage and loss	26.8	31.3	22.3	19.8	34.6	23.8	27.9	32.8	35.9	31.9	24.8	27.8	33.6	26.0	30.1	52.8	28.3
Total production	325.7	319.3	296.4	300.0	342.4	322.0	357.7	354.6	365.2	342.3	302.9	340.6	355.1	333.9	362.6	407.1	361.5

SOURCE: Potato Facts, ERS, USDA, 1987.

TABLE 11. NONFOOD USES OF POTATOES AS A PERCENTAGE OF ANNUAL PRODUCTION, UNITED STATES, 1980-1986

Category	1980	1981	1982	1983	1984	1985	1986	Average
				percent				
Shrinkage and home use	8.18	8.16	9.46	7.79	8.31	12.96	7.84	8.86
Feed	1.29	1.05	1.73	1.14	1.65	2.73	1.45	1.68
Seed	7.96	7.32	6.81	7.65	7.48	6.17	7.05	7.18
Total	17.44	16.53	18.00	16.57	17.44	21.85	16.35	17.71

SOURCE: Adapted from Table 10.

113.3 and 122.3 pounds per capita during the period from 1970 to 1985 (Table 12). Preliminary consumption estimate for 1986 was 124.3 pounds. The annual variation is primarily due to annual changes in production which determines price. Low production years like 1973, 1980, and 1981 tend to result in higher prices which limits or rations consumption.

Consumption Trends

The per capita composition of potato consumption has changed significantly during the period from 1970 to 1986. Fresh (tablestock) consumption has decreased from 62.3 pounds in 1970 to less than 50 pounds in the 1980s. Fresh consumption has been replaced with processed potato products, primarily frozen products. Processed consumption increased from 58.5 in 1970 to 75 pounds in 1985. Frozen consumption increased from 27.1 pounds in 1970 to over 44 pounds in 1985. The shift from fresh to frozen products can be attributed to several factors. The two major factors being rising disposable incomes and an increasing percentage of women in the work force. Both of these factors have contributed to an increased demand for convenience foods and for food consumed away from home (Eugene Jones, 1980).

Fast-food restaurants have capitalized on this increased demand for convenience food and have probably been the most instrumental factor in the increased demand for frozen french fries. Per capita consumption for other processed potato products, canned, chips, shoestring, and dehydrated products has been more stable. Canned potato consumption has decreased slightly to between 1.8 and 1.9 pounds. Chips and shoestrings fluctuated between 16 and 18 pounds throughout the period, with a slight strengthening during the 1980s. Dehydrated consumption stabilized between 9.4 and 11 pounds since 1978 as compared to increased consumption from 1970 to 1975. The increase from 1974 to 1976 may be biased upwards as

TABLE 12. PER CAPITA CONSUMPTION OF POTATOES AND POTATO PRODUCTS, UNITED STATES, 1970-1986

Year	Total	Fresh	Processed	Processed			
				Frozen	Canned	Chips[1]	Dehydrated
	------------- lbs. per capita -------------						
1970	120.8	62.3	58.5	27.1	2.0	17.4	12.0
1971	115.9	56.1	59.8	28.2	2.1	17.2	12.3
1972	118.9	57.9	61.0	29.8	2.1	16.7	12.4
1973	115.3	52.4	62.9	31.4	2.2	16.3	13.0
1974	118.0	49.3	68.7	36.2	2.3	15.7	14.5
1975	119.7	52.6	67.1	35.0	2.0	15.5	14.6
1976	123.2	49.4	73.8	39.7	2.0	15.8	16.3
1977	122.2	50.1	72.1	42.3	2.2	16.2	11.4
1978	118.3	46.1	72.2	41.4	2.3	16.8	11.7
1979	120.9	49.6	71.3	41.6	2.1	16.9	10.7
1980	115.1	51.0	64.1	36.1	1.9	16.7	9.4
1981	113.3	45.7	67.6	38.4	1.8	16.8	10.6
1982	116.1	46.6	69.5	40.3	1.9	17.2	10.1
1983	117.6	49.9	67.7	38.3	1.8	17.9	9.7
1984	120.3	48.8	71.5	41.6	1.8	18.1	10.0
1985	121.6	46.6	75.0	44.3	1.9	17.7	11.1
1986	124.3	49.6	74.7	44.3	1.8	18.1	10.5

[1]Includes shoestrings.

SOURCE: Potato Facts, ERS, USDA, 1987.

there was a significant decrease in exports which increased inventories. The consumption estimates may not have totally accounted for the increased inventories and may be overstated (Hamm, 1985).

The rapid shift from fresh to frozen potato products is not expected to continue. The shift has slowed significantly in the last decade. The rapid growth in the frozen market during the 1970s is generally believed to be caused by the escalating demand for french fries by baby boomers dining at fast-food establishments (Buteau, 1986). The growth in the frozen market is slowing as the percentage of young people decrease and as the rate of women joining the work force slows.

Historical market shares of fresh and frozen potatoes as a percent of total per capita consumption are presented in Figures 8 and 9. The historical market share of fresh potatoes was statistically

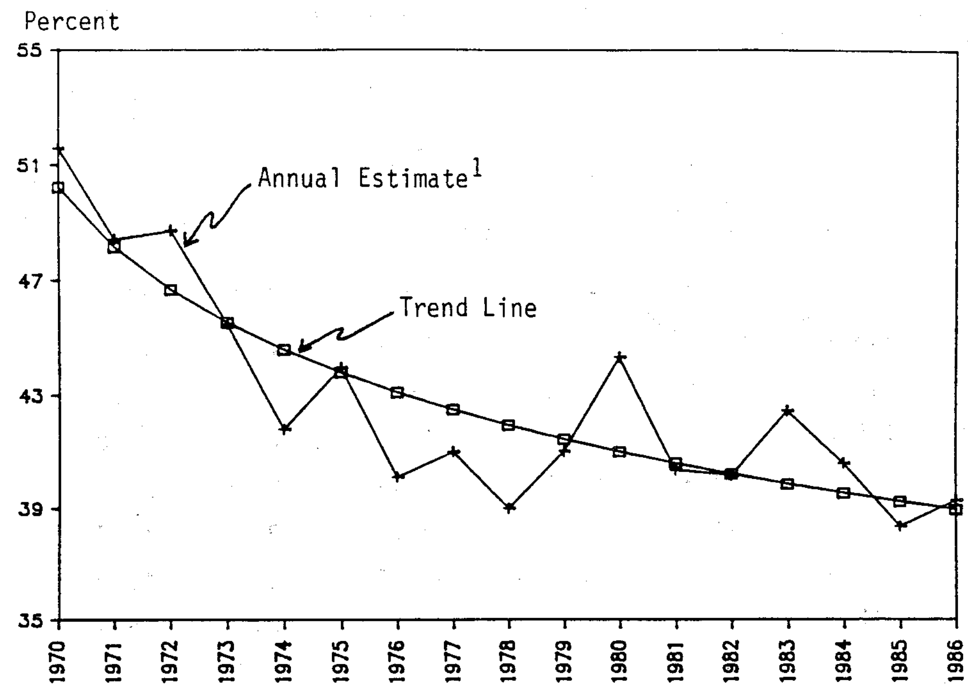

Figure 8. Fresh Potato Market Share, Percent of Domestic Consumption, 1970-1986

[1]SOURCE: Potato Facts, Economic Research Service, USDA, 1987.

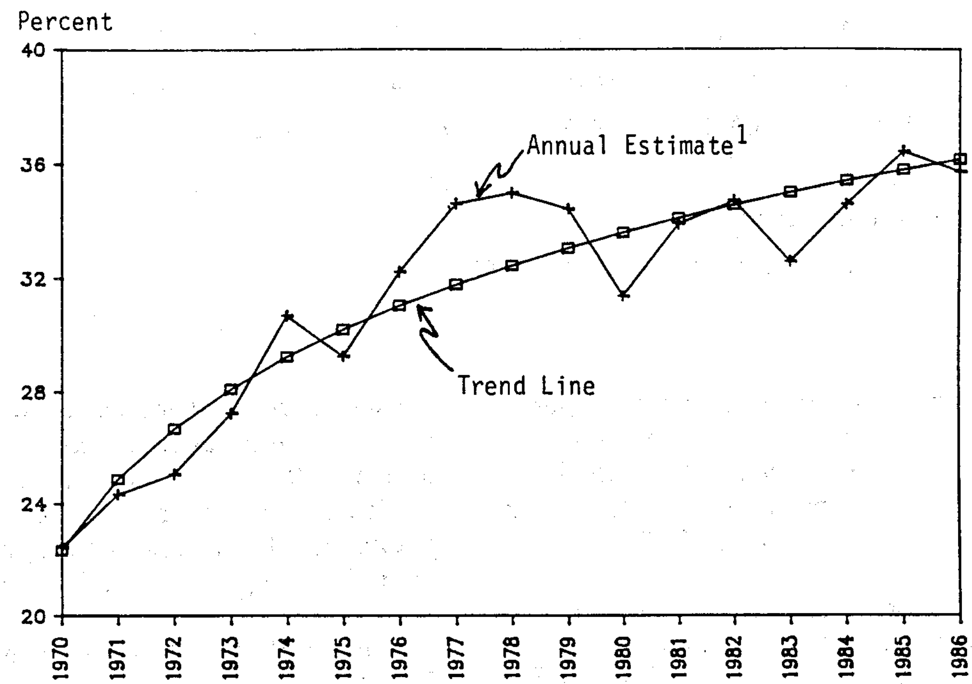

Figure 9. Frozen Potato Market Share, Percent of Domestic Consumption, 1970-1986

[1]SOURCE: Potato Facts, Economic Research Service, USDA, 1987.

estimated by the following equation:

$$FHMS = 53.79 - 5.15\ LN(t) \qquad (1)$$

where:

FHMS = Market share of fresh potatoes in percent

LN(t) = The natural log of t

t = time, 1968 = 0

Fresh potato market share is modeled by the following equation:

$$FRMS = 17.97 + 6.29 + LN(t) \qquad (2)$$

where:

FRMS = Market share of frozen potato products in percent

LN(t) = The natural log of t

t = time, 1968 = 0

The logarithmic time function illustrates that as time progresses the annual rate of change decreases. Figures 8 and 9 graphically show that the change in market share is gradually slowing. In 1970, based on the trend line, the fresh market share was decreasing 2.09 percentage points annually. By 1985 the fresh market share was decreasing at a rate of only .29 percentage points annually. The frozen market share was increasing by 2.55 percentage points annually. By 1985 the rate of increase slowed to 0.35 percentage points annually (Table 13).

Projections

Future market shares for fresh and frozen potato products are unclear. Changing population demographics and future changes in consumer tastes and preferences are unpredictable. One significant change is that the American population is aging. Prior data (Buteau,

TABLE 13. ANNUAL CHANGE IN FRESH AND FROZEN POTATO MARKET SHARE, PERCENTAGE POINTS, 1970, 1975, 1980 AND 1985

Year	Fresh	Frozen
1970	-2.09	2.55
1975	- .69	.84
1980	- .41	.50
1985	- .29	.36

SOURCE: Adapted from trend analysis, Equations 1 and 2.

1986) report that teenagers and young adults where the largest consumers of french fried potatoes. Consequently, with an aging population there is some speculation that consumption of frozen potato products might decline. However, it is quite possible that as middle age and younger Americans age they might maintain their existing tastes and preferences and continue to be avid consumers of frozen potato products.

Market share of fresh potato consumption is expected to decline to 37.44 percent by the year 2000, assuming present trends continue (Table 14). Frozen potato market share was projected to increase to 37.88 percent by the year 2000. These market shares were projected based on historical market patterns from 1970 to 1986 and were estimated using the mathematical models presented in the prior section. Market shares for canned, chips and shoestrings, and dehydrated products were assumed to remain constant, as no trends were detected, and are equivalent to the average of 1978-1986 levels. Total per capita consumption was estimated to remain constant as no trend was detected. Historical and projected 5-year per capita average consumption estimates are presented in Table 15.

Total domestic consumption was projected to expand to 322 million cwt. by the year 2000, an increase of 10.9 percent from 1985 (Table 16). Population increases all the primary factor behind the growth in consumption. Fresh consumption was projected to expand to 120.7 million cwt. by the year 2000, a 6.9 percent increase from 1985. Decreased per-capita-consumption of fresh potatoes was more than offset by population growth. Frozen potato demand was projected to expand to 122.1 million cwt., a 16.3 percent increase from 1985.

TABLE 14. HISTORICAL AND PROJECTED MARKET SHARES FOR POTATO PRODUCTS, FIVE-YEAR AVERAGES, 1970-2005

Year	Fresh	Frozen	Canned	Chips[1]	Dehyrated
			percent		
1970-74	47.2	26.0	1.8	14.2	10.9
1975-79	41.0	33.1	1.8	13.4	10.7
1980-84	41.6	33.4	1.6	14.9	8.6
1985-89[2]	38.5	36.6	1.6	14.9	8.9
1990-94[2]	37.4	38.0	1.6	14.9	8.6
1995-99[2]	36.5	39.1	1.6	14.9	8.8
2000-04[2]	35.6	40.2	1.6	14.9	8.8

[1]Includes shoestrings potatoes.
[2]Projected.

SOURCE: Table 12 and projections derived from Equations 1 and 2, p. 19.

TABLE 15. HISTORICAL AND PROJECTED PER CAPITA CONSUMPTION OF POTATO PRODUCTS, FIVE-YEAR AVERAGES, 1970-2005

Year	Total	Fresh	Frozen	Canned	Chips	Dehydrated
	- - - - - -	- - - - - -	- -	lbs. per capita	- - - - - -	- - - - - -
1970-74	117.8	55.6	30.6	2.1	16.7	12.8
1975-79	120.9	49.6	40.0	2.1	16.2	12.9
1980-84	116.5	48.4	38.9	1.8	17.3	10.0
1985-89[1]	119.4	46.4	43.7	1.9	17.7	10.5
1990-94[1]	118.9	44.5	45.1	1.9	17.7	10.4
1995-99[1]	118.9	43.4	46.5	1.9	17.7	10.4
2000-04[1]	118.9	42.4	47.7	1.9	17.7	10.4

[1]Projected.

SOURCE: Derived from Table 14, p. 20.

TABLE 16. HISTORICAL AND PROJECTED UNITED STATE CONSUMPTION OF POTATOES AND POTATO PRODUCTS, FIVE-YEAR AVERAGES, 1970-2005, MILLION CWT.

Year	US Population	Total	Fresh	Frozen	Canned	Chips	Dehydrated
	million	- - - - - -	- - - - - -	- -	million cwt.	- - - - - -	- - - - - -
1970-74	209.7	246.95	116.50	64.08	4.49	34.94	26.94
1975-79	220.4	266.35	109.22	88.15	4.67	35.80	28.50
1980-84	232.5	270.84	112.55	90.52	4.28	40.31	23.17
1985-89[1]	243.3	290.65	112.90	106.38	4.54	42.17	25.65
1990-94[1]	253.8	301.74	111.80	114.50	4.72	44.96	26.40
1995-99[1]	263.0	312.74	112.95	122.42	4.89	46.60	27.40
2000-04[1]	271.0	322.30	114.01	129.39	5.04	48.02	28.20

[1]Projected.

SOURCE: Derived from Table 15, p. 21. Population statistics from Bureau of the Census, 1986.

This increase in demand was a result of increased per-capita-consumption and population increases. Projected usage of canned, chips and shoestrings, and dehydrated products were estimated at .53, 4.67, and 2.85 million cwt., respectively.

Foreign Trade

Exports

Exports have fluctuated widely over the last 10 years. Exports peaked in 1978 at 11 million cwt. (fresh weight equivalent), then dropped below 7 million cwt. in 1984 before rebounding to 10 million cwt. in 1986. Several different underlying factors were present. First, tablestock and dehydrated exports dropped considerably from 1977 to 1986. Secondly, increases in frozen exports have offset the declines in tablestock and dehydrated products in recent years. Tablestock exports decreased from 3.5 million cwt. in 1977 to only 1.0 million cwt. in 1986. Exports of dehydrated products decreased from 6.9 million cwt. in 1979 to 3.6 million cwt. in 1986. Frozen potato exports increased from .8 in 1977 to 5.2 million cwt. in 1986 (Table 17).

Canada is the primary importer of fresh potatoes. In 1985 Canada imported 44,515 metric tons from the United States. This accounted for 90.7 percent of U.S. fresh potato exports. Mexico accounted for 2,224 metric tons, or 4.5 percent, and other Latin American countries accounted for 1,112 metric tons or 2.3 percent (Tables 18 and 19).

Japan is the primary importer of U.S. frozen potatoes, accounting for 50,673 of the total 64,243 metric tons of frozen potato exports. Japan's market share has increased from 71.4 percent in 1982 to 78.6 percent in 1985 (Tables 20 and 21). Singapore and Hong Kong imported 2,978 and 4,729 metric tons of frozen potatoes in 1985. These three Pacific Rim countries and Canada accounted for 92.9 percent of U.S. frozen potato exports in 1985. The western style fast-food industry in Japan is credited with the large increase in demand

TABLE 17. POTATO EXPORTS, UNITED STATES, (FRESH WT. EQUIVALENT)

Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	million cwt.									
Table	3.5	2.9	1.8	2.6	2.1	1.8	1.4	1.0	.8	1.0
Seed	.0	.0	.2	.2	.2	.1	.1	.1	.1	.1
Dehydrated	4.8	6.6	6.9	4.3	4.6	3.3	3.5	2.6	2.5	3.6
Frozen	.8	1.5	1.8	2.2	2.4	2.6	3.2	3.2	3.9	5.2
Total	9.1	11.0	10.6	9.3	9.3	7.8	8.2	6.9	7.4	10.0

SOURCE: Potato Facts, ERS, USDA, 1987.

TABLE 18. MAJOR IMPORTERS OF FRESH POTATOES, UNITED STATES, 1982-1985

Year	World	Canada	Mexico	Other Latin Amer.
	- - - - - - - - - -	metric tons	- - - - - - - - - -	
1982	88,308	82,427	1,268	3,636
1983	68,354	59,686	4,669	3,008
1984	40,468	34,638	3,792	1,214
1985	49,080	44,515	2,224	1,112

SOURCE: Foreign Agricultural Service, 1987

TABLE 19. MARKET SHARE OF FRESH POTATO EXPORTS BY COUNTRY, UNITED STATES, 1982-1985

Year	Canada	Mexico	Latin Amer.	Total
	- - - - - - - - - -	metric tons	- - - - - - - - - -	
1982	93.3	1.4	4.1	98.9
1983	87.3	6.8	4.4	98.6
1984	85.6	9.4	3.0	98.0
1985	90.7	4.5	2.3	97.5

SOURCE: Adapted from Table 18.

TABLE 20. MAJOR IMPORTERS OF FROZEN POTATOES, UNITED STATES, 1982-1985

Year	World	Japan	Singapore	Hong Kong	Canada
	metric tons				
1982	52061	37166	1638	4029	2763
1983	64638	45860	2701	3974	2802
1984	64253	50673	2617	3683	3403
1985	79589	62563	2978	4729	3669

SOURCE: Foreign Agricultural Trade of the United States, ERS, USDA, various issues.

TABLE 21. MARKET SHARE OF FROZEN POTATO EXPORTS BY COUNTRY, UNITED STATES, 1982-1985

Year	Japan	Singapore	Hong Kong	Canada	Total
	percent				
1982	71.4	3.1	7.7	5.3	87.6
1983	70.9	4.2	6.1	4.3	85.6
1984	78.9	4.1	5.7	5.3	94.0
1985	78.6	3.7	5.9	4.6	92.9

SOURCE: Adapted from Table 20.

for U.S. french fries. This trend is expected to continue not only in Japan, Hong Kong, and Singapore but also in Malaysia and South Korea as these countries acquire and adopt more western-style food habits (Buteau, 1986). Population increases will also contribute to a growing demand for frozen potato products.

Imports

Potato imports increased over threefold from 1977 to 1986, from 1.8 million cwt. to 6.3 million cwt. Increases were due to increasing amounts of fresh potatoes being imported and to a lesser extent to increases in frozen potato imports. Imports of seed potatoes have ranged between .2 and 1.6 million cwt. annually. A small amount of dehydrated potatoes was imported, .1 million cwt. in 1977 increasing to .4 million cwt. by 1986 (Table 22). The primary sources of imported potatoes were shipments from Canada to Northeast United States. From 1982 to 1985 Canada accounted for over 98 percent of U.S. imports (Table 23).

Net Trade

Prior to 1981 the U.S. was a net exporter of fresh potatoes (Figure 10). Imports of fresh potatoes exceeded exports in 1981 and have continued to grow while exports of fresh potatoes have continued to diminish. Seed imports have exceeded exports; however, imports have been erratic, dropping considerably in 1981 (Figure 11). Imports of dehydrated potatoes have been minimal compared to exports. The trend is upward for imports and downward for exports (Figure 12). Frozen potato exports exceed imports; however, both exports and imports have seen tremendous growth in the last ten years. The trade difference is increasing with exports of frozen potatoes exceeding imports by .7 million cwt. in 1977 and by 1986 the United States exported 3.5

TABLE 22. POTATO IMPORTS, UNITED STATES (FRESH WT. EQUIVALENT) 1977-1986

Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	million cwt.									
Table	.9	.8	1.3	2.3	3.6	2.8	2.1	3.6	2.3	4.0
Seed	.7	.6	.6	1.6	1.4	.7	.7	1.1	.6	.2
Dehyd.	.1	.1	.0	.1	.1	.1	.2	.3	.3	.4
Frozen	.1	.3	.3	.3	.4	.6	1.0	1.5	1.7	1.7
Total	1.8	1.9	2.2	4.3	5.5	4.2	4.0	6.4	5.0	6.3

SOURCE: Potato Facts, ERS, USDA, 1987.

TABLE 23. UNITED STATES FRESH POTATO IMPORTS, WORLD, CANADA, AND CANADA's MARKET SHARE, 1982-1985

Year	World	Canada	Market Share
	- - metric tons	- -	- -percent- -
1982	138,510	138,413	99.9
1983	115,554	113,514	98.2
1984	192,203	190,708	99.2
1985	140,807	139,792	99.3

SOURCE: Foreign Agricultural Service, 1987.

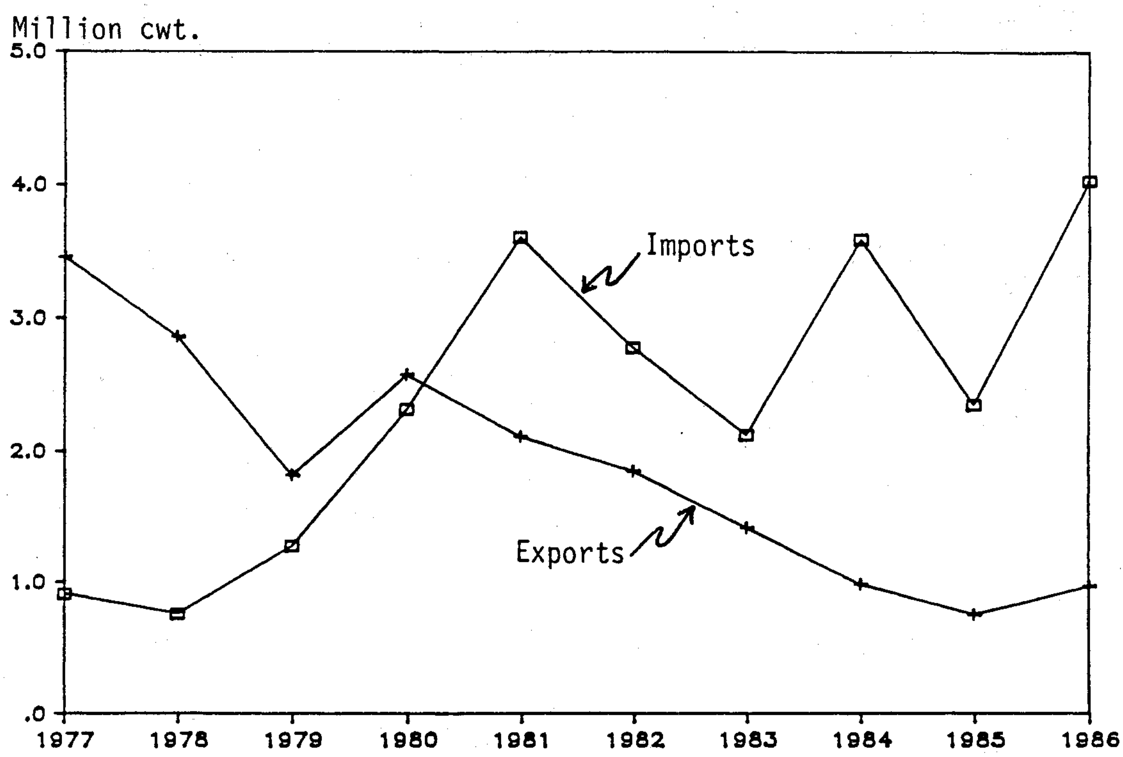

Figure 10. Tablestock Potatoes, Imports and Exports, United States, 1977-1986

SOURCE: Adapted from Potato Facts, Economic Research Service, USDA, 1987

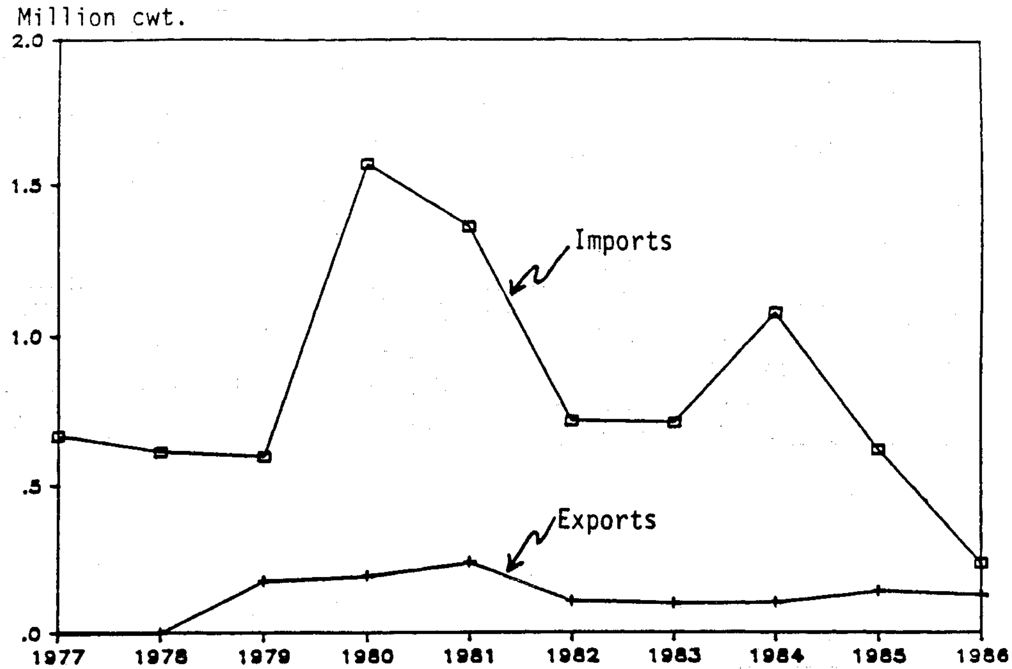

Figure 11. Seed Potato Imports and Exports, United States, 1977-1986

SOURCE: Adapted from Potato Facts, Economic Research Service, USDA, 1987.

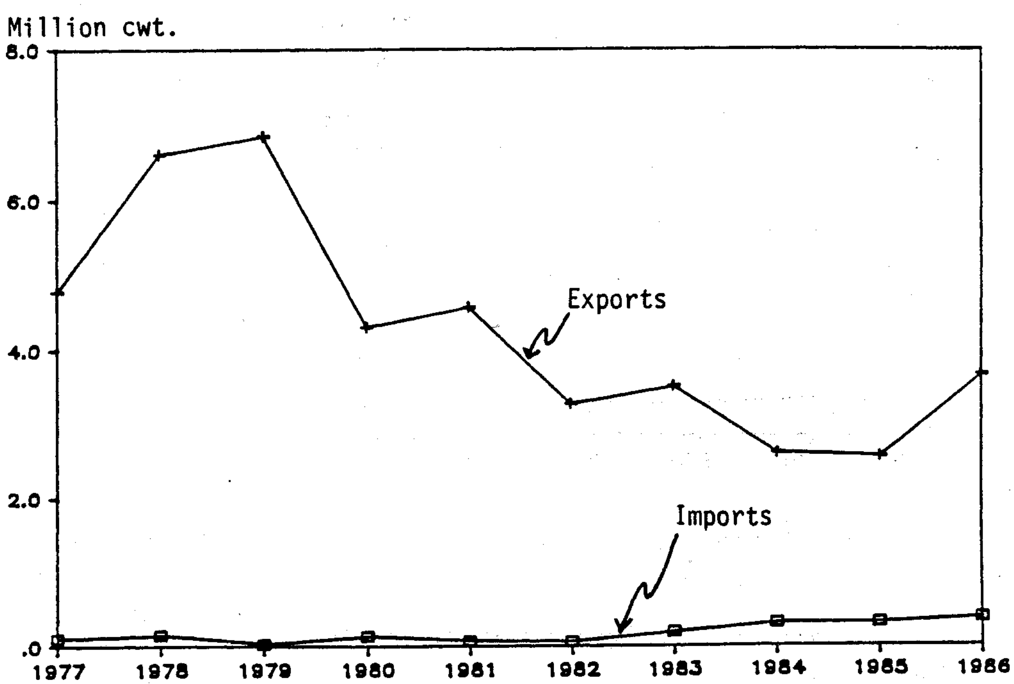

Figure 12. Dehydrated Potato Imports and Exports, United States, 1977-1986

SOURCE: Adapted from Potato Facts, Economic Research Service, USDA, 1987.

million cwt. more than it imported (Figure 13).

Total potato exports have consistently exceeded imports; however, the net trade balance is narrowing. Total exports exceeded imports by only 3.7 million cwt. in 1986 compared to 7.3 million cwt. in 1977 (Figure 14). The primary factor causing the declining trade balance in fresh potatoes is the increase in imports from Canada to Northeast United States.

Relative to overall U.S. potato production foreign trade is minimal. Net exports accounted for only 2.1 percent of annual production in 1977, compared to only 1 percent by 1986. Foreign trade is much more important for certain segments in the industry. In 1977, the United States exported 2.2 percent of its tablestock, 14.25 percent of the dehydrated production, and 0.9 percent of the frozen production (Table 24). By 1986, the U.S. as a percent of

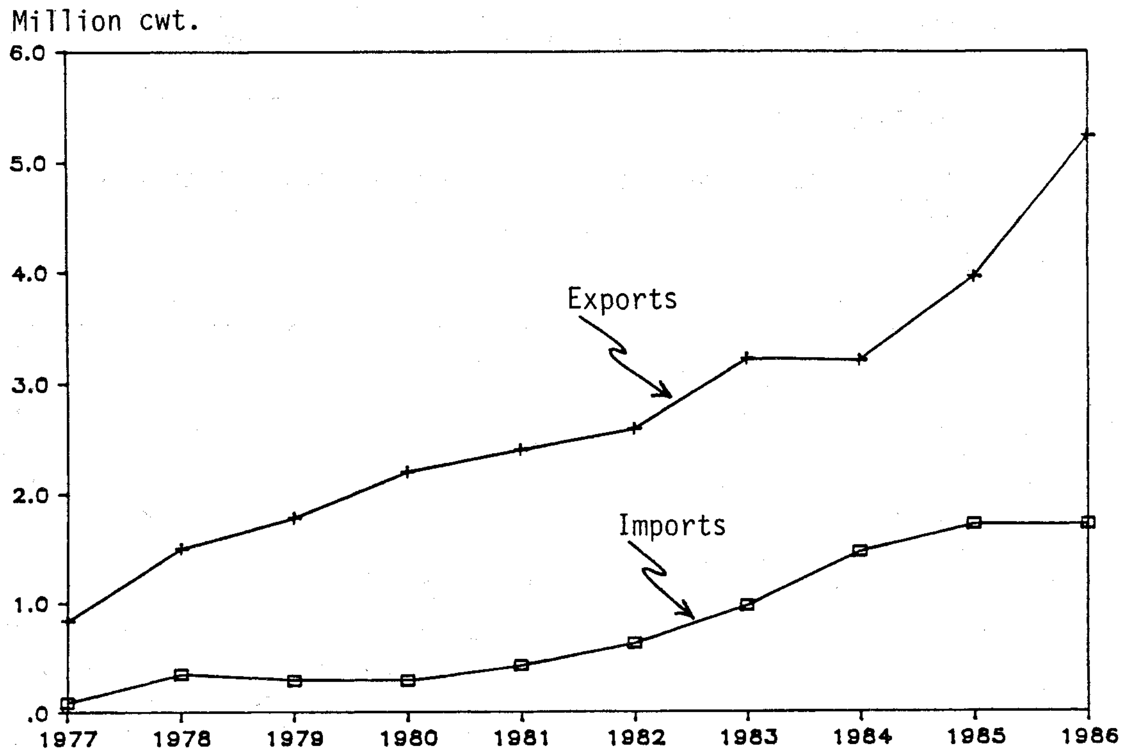

Figure 13. Frozen Potato Exports and Imports, Fresh Weight Basis, United States, 1977-1986

SOURCE: Adapted from Potato Facts, Economic Research Service, USDA, 1987.

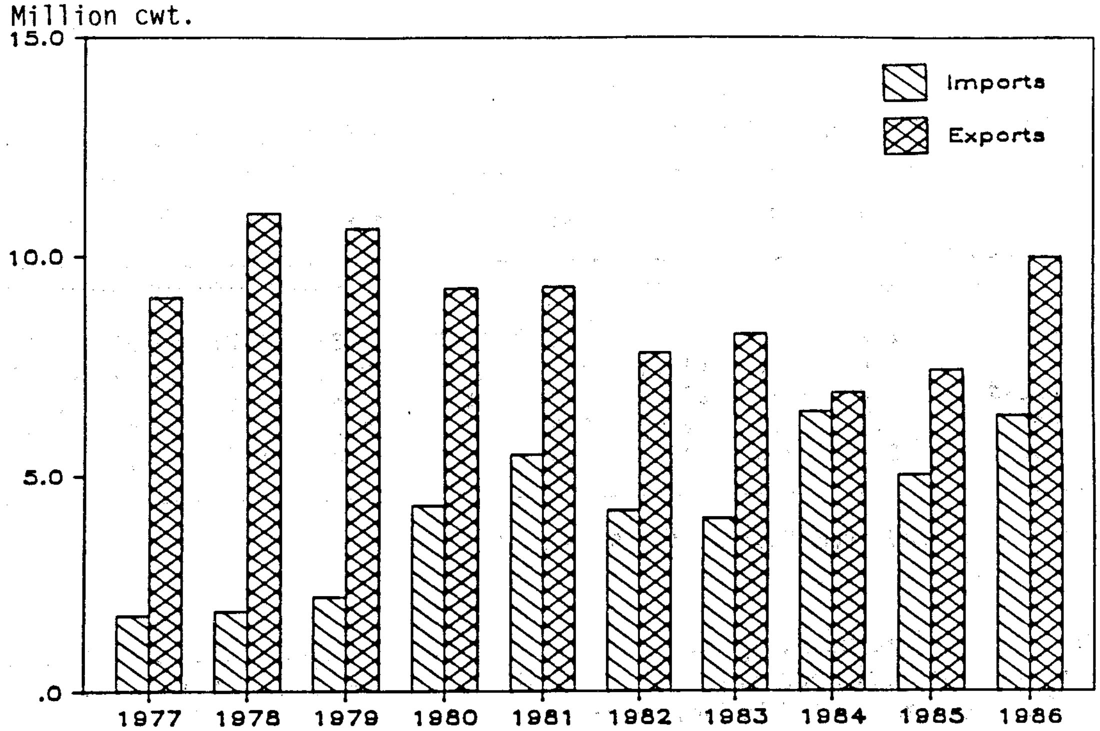

Figure 14. Potato Exports and Imports, Fresh Weight Basis, United States, 1977-1986

SOURCE: Adapted from Potato Facts, Economic Research Service, USDA, 1987.

production by category had net imports of 2.8 percent for fresh, 11.5 percent for dehydrated products, and 3.7 percent of its frozen potato production. The foreign trade industry is much more important to the dehydrating industry. Exports of dehydrated products accounted for 19.3 percent of production in 1979 before retrenching in the 1980s.

Supply Response

Producer behavior in the potato production sector is quite different from behavior in the production of other agricultural commodities. Potato production is more specialized than grain production. The specter of specialization includes more specialty equipment and more requirements on production conditions such as soil type and moisture levels. This specialization and the specific requirements of production limit crop substitution in major production areas. The higher level of specialization results in higher overhead costs from specialized planting, harvesting, and storage equipment and facilities. Because of this higher fixed cost and a lower degree of substitution to other crops, potato producers tend to be less responsive to price changes in their planting decisions (Koo, 1984).

Producer behavior from 1965 to 1986 was statistically analyzed to identify significant factors in producer decision making in overall U.S. potato production and differences between primary fall production states. The impact of potato price levels, competing crops (primarily sugar beets and edible beans), and annual trends

TABLE 24. NET EXPORTS (IMPORTS) OF POTATOES AS A PERCENT OF PRODUCTION BY CATEGORY

Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	percent									
Table	2.2	1.9	.5	.3	(1.3)	(0.8)	(0.7)	(2.3)	1.3	(2.8)
Seed	(2.6)	(2.5)	(1.9)	(5.7)	(4.5)	(2.5)	(2.4)	(3.6)	(1.9)	(0.4)
Dehdrated	14.3	19.4	22.2	14.7	15.0	11.5	12.4	8.2	7.5	11.5
Frozen	.9	1.4	2.0	2.6	2.3	2.4	2.8	1.9	2.2	3.7
All potatoes	2.1	2.5	2.5	1.6	1.1	1.0	1.3	.1	.6	1.0

SOURCE: Adapted from Tables 11, 18, and 23.

were analyzed with respect to producer behavior. Producer behavior was measured by acreage planted in individual years.

Eighty-eight percent of the variation in total U.S. fall potato acreage between 1965 and 1980 was explained by the price of potatoes the previous year, planted acreage the previous year, and the price of one competing specialty crop. The price of sugar beets was a significant factor in determining producer planting behavior. At high sugar beet prices producers tended to shift production away from potatoes. The converse is also true when sugar beet prices are low, producers reduce sugar beet acreage as they shift to potato production. Unlike grains, sugar beets are considered a high risk, management-intensive, specialty crop. Although not requiring as specialized equipment as potato production, they do compete with them because of their high profit potential.

Producer acreage response was inelastic; i.e., plantings change by less than 1 percent when price increased by 1 percent. The elasticity coefficient was estimated at .30, meaning a 1 percent increase in potato prices resulted in only a 0.30 percent increase in potato acreage. This estimate of inelastic supply is consistent with other investigations (Koo, 1984).

Producer behavior in the principal fall producing states was similar to overall national behavior. Production in every state was inelastic. Prices of competing specialty crops were significant in Idaho, Minnesota, and North Dakota. Substitution with other crops probably exists in the other states but due to a multitude of planting alternatives in the specialized producing areas specific competing crops could not be found to be statistically significant. The model explained 86 percent of the variation in Colorado planting; 74 percent for Idaho; 96 percent for Maine; 50 percent for Michigan, 90 percent for Minnesota, 65 percent for North Dakota, 55 percent for Oregon; 91 percent for Washington; and 50 percent in Wisconsin. The model tended to be more efficient in the more major producing states as Washington and Idaho than the less major states of Michigan and Wisconsin.

North Dakota and Minnesota potato supply responses are both characterized as being inelastic, with elasticity coefficients of .22 and .26, respectively. These elasticities indicate that during the 1965 to 1980 time period producers tended to increase/decrease potato acreage by .22 and .26

percent for each 1 percent increase/decrease in lagged potato price. Also, in both North Dakota and Minnesota, sugar beets and edible beans competed for potato acreage.

Idaho's producer supply response was very similar to the United States as a whole. Substitution exists between sugar beets and potatoes. Supply elasticity was also very similar at 0.34. Oregon and Washington tended to be less inelastic, 0.63 and 0.47 and substitution of specialty crops was not significant. Colorado, Maine, Michigan, and Wisconsin were very inelastic. This inelastic supply behavior in Colorado could be a result of a very strong positive yearly trend in plantings and in Maine a result of a strong negative annual decline in plantings.

The lower price inelasticity for North Dakota relative to Idaho, Oregon, and Washington may indicate that North Dakota's production may be less sensitive to changing price levels. However, North Dakota producers have tended to shift production to edible beans and sugar beets when prices have been favorable (Table 25).

Economic Feasibility Analysis

The economic feasibility analysis of expanded potato processing in North Dakota will be limited to frozen potato processing. Expansion of the chipping and dehydrating industry in North Dakota on a broad scale would encounter significant marketing problems. The chipping industry is characterized by being a consumption located industry. That is, processing is typically located in major consumption areas. Transportation is the primary factor for the location of chipping plants. Potato chips are a low density product, resulting in high transportation costs for the finished product. Additionally, transportation and handling is minimized in order to reduce breakage. Major chippers also rely on supplies from summer and spring potato producing states for processing prior to supplies of fall potatoes. This is not to state that specialty or small processors cannot be successfully located in North Dakota. It does suggest that it would be unlikely that major chippers could be encouraged to locate in North Dakota due to these manufacturing considerations.

The dehydrating industry is in a retrenchment phase, with processing declining from over 40 million cwt. in 1976 to 28 million cwt. in 1980. Processing has not exceeded 30 million cwt. throughout the seven-year period from 1980 to 1986. Dehydrators are facing declining per capita consumption and declining exports. Increased population growth is not expected to compensate for the reduced per capita consumption.

Frozen potato processing has been, is now, and will be expected to remain a growth industry. The domestic demand for frozen potatoes is expected to increase by 21 percent over the next 15 years. This growth is expected from two factors. First, increased per capita consumption and second, increased population growth. In addition, exports of frozen potato products are increasing.

The economic feasibility analysis of a North Dakota based frozen potato processing plant will be presented in two major sectors. The first major sector will be economic profitability which includes cost, revenue, and a profitability analysis. The second section will address the locational competitiveness of a North Dakota plant, incorporating regional differences in transportation and processing costs.

Economic Profitability

Model Plant Characteristics

A model plant was simulated to process 60,000 pounds per hour of frozen potato products. Consultation with an

TABLE 25. ESTIMATED ACREAGE RESPONSE FOR THE UNITED STATES AND PRINCIPAL PRODUCING STATES, FALL POTATOES, 1965-1986[1]

Variable	United States	Colorado	Idaho	Main	Michigan	Minnesota	North Dakota	Oregon	Washington	Wisconsin
Intercept	-6.68	-411.74	-34.24	6404.09	9.53	-.10	48.03	-39.09	-28.25	11.44
P_{t-1}	201.17	3.92	63.45	1.72	.73	12.86	16.39	19.39	28.79	.33
S_{t-1}	-11.46	--	-3.53	--	--	-1.06	-.91	--	--	--
Z_{t-1}	--	--	--	--	--	-.63	-1.76	--	--	--
Q_{t-1}	.81	.97	.93	.17	.75	.94	.60	1.11	.86	.78
t	--	.21	--	3.19	--	--	--	--	--	--
R^2	.88	.86	.74	.96	.50	.90	.65	.55	.91	.50
SE	33.20	2.94	12.23	5.35	4.13	4.61	6.93	5.67	6.74	3.59
Elasticity	.30	.14	.34	.03	.04	.26	.22	.63	.47	.01

[1]General form of model: Acreage planted_t = Intercept + β_1 (P_{t-1}) + β_2 (S_{t-1}) + β_3 (Z_{t-1}) + β_4 (Q_{t-1}) + β_5 t

where: P_{t-1} = Deflated potato price received by farmers, lagged one year.
S_{t-1} = Deflated sugarbeet price, lagged one year.
Z_{t-1} = Deflated edible bean price, lagged one year.
Q_{t-1} = Area of potatoes planted, lagged one year.
t = Year.
SE = Standard error, 1,000 acres.
Acreage Planted = Acreage planted in year t, t=1965 to 1986, in 1,000 acres.

SOURCE: Current estimates made by the authors, 1988.

engineering firm indicated this was the current industry standard for new processing plants. This size plant would capture economies of size with current technology available. Output was estimated at 25,000 pounds per hour of high solids french fries, 25,000 pounds per hour of medium solids french fries, and 10,000 pounds per hour of formed by-products. Overall, a plant recovery rate or yield was estimated at 51 percent. The 51 percent recovery rate is higher than estimated in earlier studies due to the inclusion of the by-product line in the modeled plant. A 51 percent recovery rate would require an incoming raw product rate of 118,000 pounds per hour.

Many of the fast-food chains require french fries with high solids (meaning lower moisture content) to minimize their frying time and to improve crispness. The primary difference between high solids and low or medium solids lines is that the high solids line has a larger dryer to achieve the lower moisture content. Because of the lower moisture content (approximately 40 percent as compared to about 45 percent for medium solids lines), high solids french fries require more energy to process, but sell for a premium price. The recovery for the entire plant is boosted to the 51 percent rate by the formed by-product line.

The formed by-product line uses the slivers and short pieces of potato that are graded out after the cutting operation in the french fry lines. These are processed and formed into various sizes and shapes such as hash brown patties, logs (tater tots), etc. The formed by-product line has a yield of approximately 50 percent.

As a rule of thumb, approximately 20 percent of the incoming raw product rate goes to waste or about 23,600 pounds/hour. This is comprised of peelings, defects, starch, and any surplus raw slivers and short pieces not used by the by-product lines. Most of the solid material is screened from the waste process water and is sold as livestock feed where markets exist. Also, starch can be extracted and sold. Approximately 32 percent of the incoming raw weight is moisture that is evaporated in the drying and frying process and emitted into the atmosphere.

Yearly plant output is expected to be 324,000,000 pounds. This volume is based on data that an average plant operates 22.5 hours per day and 240 days per year. Yearly raw product usage would be approximately 318,000 tons of potatoes.

Construction Costs

Total costs were estimated at $63.45 million (Table 26). Building costs were estimated at $15 million, and includes processing plant, supporting facilities, and an 80,000 square foot frozen product warehouse. Equipment was estimated at $37 million. Equipment includes state-of-the-art automatic defect removal equipment. This equipment is becoming common place in the industry. Miscellaneous costs were estimated at $3.2 million and includes site work, paving, fencing, waste handling systems, etc. Engineering fees were estimated at $1.5 million. A 10 percent contingency has also been included to cover unexpected expenses which often occur. Total plant construction costs excluding land were estimated at $62,370,000. The land requirement was estimated at 80 acres for plant, warehouse, parking, and yard areas. An additional 350 acres was required for a spray field. Waste water containing some starch and pieces of potato that pass through the screening process at the plant can be disposed of by irrigation. Some plants use existing city sewer treatment facilities which eliminates the need for the spray field. The total land requirement was estimated at 430 acres at $2,500/acre for a total land cost of $1.075 million. Land

TABLE 26. ESTIMATED BUILDING AND EQUIPMENT COST FOR MODEL FROZEN POTATO PROCESSING PLANT, NORTH DAKOTA, 1988

Building Cost	$15,000,000
Equipment	$37,000,000
Miscellaneous Capital	$3,200,000
Engineering Fees	$1,500,000
Total	$56,700,000
Contingency, 10%	$5,670,000
Land	$1,075,000
Total Estimated Plant Cost	$63,445,000

SOURCE: Food Plant Engineering, Inc., Yakima, WA, 1988.

costs can be quite variable. A processing plant of this nature and size would likely be located in a rural area where land values are lower. Relative to total plant costs, land costs are minimal. Thus, severe over or underestimation would not affect total processing costs significantly.

Cost Analysis

A summary of operating costs for the model plant is presented in Table 27. Processing costs, excluding cost of new potatoes, was estimated at $.153 per pound of finished product.

Annualized Capital Charge

The annualized capital charge was estimated at $9.3 million. An annualized capital recovery factor of .1441 is used to estimate a constant annual charge for depreciation and interest on fixed plant investment. The capital recovery factor is based on a plant life of 15 years and an 11.65 percent interest rate. The 11.65 percent rate is the average rate, 1982-1986, of industrial bonds (Survey of Current Business, U.S. Department of Commerce, 1988). The useful life of the equipment was estimated at 15 years and the building at 25 years. However, a 15-year planning horizon was used for the entire plant in estimating all capital costs. The shorter, useful life was used for the buildings, even though the useful life is longer, because the primary investment is in the equipment. Also, potential plant obsolescence due to changes in technology could shorten the useful life and value of the buildings; justifying the use of a shorter planning horizon for the entire investment. A zero salvage value was used for buildings and equipment.

Interest on Net Working Capital

Interest on net working capital was estimated at $2.5 million annually. Net working capital requirement was estimated at 25 percent of annual sales. Assuming an end product price of $.256/lb., annual sales of 324 million lbs., net working capital was estimated at $21.5 million. An

TABLE 27. SUMMARY OF ANNUAL COST FOR MODEL FROZEN POTATO PROCESSING PLANT, NORTH DAKOTA, 1988

	(dollars)
Annualized Capital Charge	9,142,425
Property Taxes	475,838
Property Insurance	838,350
Premise Liability	18,560
Building Maintenance	330,000
Interest on Net Working Capital	2,500,673
General and Administrative Overhead	6,256,874
Total Fixed Cost	19,562,659
Labor	6,400,000
Fringe Benefits	1,920,000
Electrical-energy charge	2,399,544
Electrical-demand charge	1,509,660
Natural Gas	2,250,707
Water	382,320
Repairs & Maintenance	2,653,200
Vegetable oil and/or animal fats	4,481,730
Packaging	8,100,000
Total Variable Cost	30,097,161
Total Processing Cost	49,659,819
Processing cost per pound of finished product	$.153

interest rate of 11.65 percent was used, which represents the 1982-1987 average U.S. industrial bond rate (Survey of Current Business, U.S. Department of Commerce, 1988).

Property Taxes

Property taxes were estimated at $150 per $1,000 of taxable property valuation. Taxable value was 10 percent of assessed value and assessed value was calculated at 50 percent of full and fair market value (North Dakota Tax Department, 1987). This estimation procedure yielded an estimated annual property tax of $475,838.

Insurance

Two different insurance costs were estimated. Property insurance was estimated at $10 per $1,000 for structures and their contents. Premise liability was estimated at $.29 per $100 of plant payroll. All insurance rates were obtained from insurance companies that handled insurance coverage for food processing firms. Insurance costs were estimated at $838,350 and

$18,500 annually for property and premise liability insurance coverage.

Labor and Fringe Benefits

Total plant personnel requirements were estimated at 350 employees comprised of 50 salaried employees and 300 hourly employees. The staffing requirements were based on the utilization of state-of-the-art automatic defect removal equipment. Automatic equipment eliminates the large labor requirements for manual product inspection and defect removal. Without the automatic defect removal equipment the hourly labor requirement could increase from 300 to 675 employees. Annual wages for salaried personnel were estimated at $32,000 and for hourly workers $16,000 for each employee. Wages were consistent with rates reported by the North Dakota Job Service (1986). Possible wage reduction could occur if a plant were located in an economically depressed region. Fringe benefits were estimated at 30 percent of labor costs. Total labor and benefit costs were estimated at $8.32 million.

General and Administrative Overhead

General and administrative costs include the salary expense of the chief executive officer, secretarial expense, travel, auditing services, legal fees, telephone, office supplies, postage, and miscellaneous expenses. Office building expenses, either ownership or leasing costs, were also included. These costs were estimated at 20 percent of all other operational expenses excluding depreciation and raw product costs. The estimate was derived from an analysis of annual financial statement reports of various food manufacturing firms.

Utility Requirements

Electricity: Electric power would be used primarily for motors operating various conveyance devices to move product through the plant, refrigeration equipment, controls, and lighting. Due to the relatively higher cost of electric resistance heating, processes that require heat such as peeling, blanching, drying and frying, the plant would utilize fossil fuels to fire a boiler to feed steam to these processes.

Kilowatt hour usage per pound of finished product was estimated at .23 KWH/pound of finished product or an average overall plant consumption of 13,800 KWH. Demand requirements were estimated at .31 KW/pound or a total of 18,000 KW. Usage (KWH) was estimated at approximately 75 percent of the demand rate. Some controlled sequencing of motor starting is required to keep within this demand rate. An electrical demand charge was calculated at $6.98 per monthly KW of demand and an energy charge of $.0322 per KWH. The electric rates were an average of three utilities serving Northeast North Dakota. Total electrical costs were estimated at $3.84 million.

Fuel: Any and all fossil fuel consumed by the plant will be used to fire a central boiler(s) used to provide heat such as steam for peeling, blanching, drying, and frying as well as any space heating required by the plant. However, natural gas may be used for direct heating of some processes such as blanching and drying. The average fuel requirement was 1750 Btu/pound of finished product. Since the boiler efficiency using natural gas, fuel oil, and coal is about the same, this heat rate should apply to all of these fuels. Total average plant consumption was estimated at 105,000,000 Btu hour or 1,050 Therms./hour. Natural gas was estimated at $.3965 per CCF.

Water: Water usage was estimated at 0.6 gallons per pound of raw product. With a product recovery rate of 51 percent, this translates to 1.18 gallons per pound of finished product. Total average water use for the plant was estimated at 70,800 gallons/hour or 1,180 gpm.

Repairs and Maintenance

Repairs and maintenance costs were based on 6 percent of initial equipment cost, resulting in an estimated charge of $2.65 million.

Miscellaneous

Other major costs were vegetable oil and/or animal fat. Before freezing, the product is partially cooked (fried) in either vegetable oil or animal fat or a combination of both. Oil type is generally specified by the buyer. Average oil content of the finished product is 5.5 percent.

Although animal fat is cheaper the price of soybean oil was used for cost estimation. A cost of $25.15 per cwt. of soybean oil was used. Cost was estimated at the average crude oil price, FOB Decatur, IL, 1985-1987, a refining margin of $6/cwt., and a delivery charge of $1.50/cwt. Other miscellaneous costs including packaging and sucrose were estimated at $.025/pound. Sucrose is sometimes used to enhance browning of the fried potato products.

Revenue Analysis

Obtaining accurate price information for the frozen potato industry is difficult. There are no government agencies that collect price data. Another problem is that the industry relies heavily on annual contracts within the institutional trade. The terms of these contracts are not disclosed.

However, there are two sources of limited price data. The American Institute of Food Distribution, Inc. reports spot prices of french fries on a monthly basis. These prices are most likely higher than the industry average as they are not net prices, and they do not include quantity and payment discounts. These prices do, however, give some insight into the pricing structure. Idaho generally receives a price premium even though contract specifications are the same. This has been accredited to two factors. First, Idaho has a long history of producing quality french fries and secondly, the Idaho Potato Board advertises nationally to create an image of Idaho potatoes being a superior good. Idaho french fry prices have varied between $.30 and $.36/lb. during 1984, 1985, and 1986. Maine and Washington reported prices were lower. Maine trades generally at a $.04 to $.08/lb. discount to Idaho (Table 28). Washington has traded up to $.06 discount to Idaho. These price differentials are not totally accounted for by economic costs. There is some justification for Washington prices to be lower as producers in that state are further from the major U.S. metropolitan areas compared to producers in Idaho but not to the extent of a $.04-.06 discount per lb.

Maine initially would seem to possess a transportation advantage over the PNW in serving the heavily populated eastern coast. This, however, has not been reflected in prices of frozen french fries. Industry sources have stated that the PNW extracts a price premium for their potato products compared to products from other producing areas. This statement is reinforced by the prices reported from the American Institute of Food Distribution, Inc.

W. Smith Grieg (1978) stated that Idaho french fries have long been considered the standard for quality and that Idaho has received a premium for their reputation. He also noted that the premium that Idaho possesses over Washington has been declining with time.

A second source of price information is the Agricultural Marketing Services, USDA (AMS, USDA) purchases of frozen potato products for their child nutrition and other domestic feeding programs. Unlike other price data from AMS, contract awards are devoid of any price premiums for potatoes produced in specific regions or for brand

TABLE 28. FROZEN FRENCH FRY PRICES, FANCY FOB ORIGIN, AS REPORTED BY THE AMERICAN INSTITUTE OF FOOD DISTRIBUTION, 1984-1986

Origin	1984	1985	1986
		$/pound	
Idaho	.31 - .35	.34 - .36	.30 - .33
Maine	.27 - .30	.26 - .29	NA
Washington	NA	.29 - .35	.24 - .29

SOURCE: American Institute of Food Distribution, 1987.

names. These contracts are awarded on a low bid basis subject to transportation considerations basis. Consequently, eastern suppliers will often receive a higher FOB price because AMS considers the higher transportation cost associated with product being moved from the PNW to the east coast.

AMS contracts awarded during 1985-1987 are listed in Tables 29, 30, and 31. Almost exclusively, accepted bids for Maine and Michigan were higher than those for the PNW. The differential is primarily due to lower transportation costs.

Annual change in frozen prices generally follow the changes in the fall potato prices. Potato prices decreased from 1984 to 1985 before rising again in 1986. Processed frozen potato prices decreased from February 1985 (1984 crop year) to March 1986 (1985 crop year) before rising in March 1987 (1986 crop year). The exception are prices of frozen round potatoes, a formed by-product, and may be due to increased competitiveness between firms as more firms market formed potato products.

Using AMS prices for the formed products and the medium solid potato lines, and the American Institute of Food Distribution prices for the high solid production lines, estimated processing margins were calculated (Table 32). The high solid lines account for 41.67 percent of production, the medium solids line 41.67 percent, and the formed product line 16.66 percent. The prices were estimated on Washington FOB prices, 1985-1987, and an average North Dakota fall potato price. Washington was selected versus Idaho because Washington prices are lower thus providing a more conservative estimate of processing margins. Baseline processing margin excluding potato price was estimated at 17.5 cents per lb. of finished product. The AMS reports indicate higher prices for products produced in Maine, Michigan, and Minnesota. A second processing margin was estimated incorporating a $.01 premium to partially reflect transportation savings as indicted by AMS bid prices.

Profitability

The analytical method used to determine economic profitability was the internal rate of return (IRR). IRR is usually thought of as the rate of return the project (investment) earns during the investment's planning horizon. An advantage of the IRR methodology over other methodologies is it takes the time value of

TABLE 29. FROZEN POTATO PRICES, ACCEPTED BID, AGRICULTURAL MARKETING SERVICE, 1985

Award Date Product	Shipping Point	Price/Case	Price/pound
		------ dollars	------
February 6,1985			
French Fries- Fry Type			
	WA	9.54	.32
French Fries- Oven Type			
	ME	8.22	.27
	WA	9.45 - 9.83	.32 - .33
September 9, 1985			
Potato, Rounds, Frozen			
	OR	7.20 - 8.09	.24 - .27
	ID	8.09	.27
	MI	7.94	.26
	ME	8.70 - 9.00	.29 - .30
November 8,1985			
French Fries- Fry Type			
	MI	7.20	.24
	ME	7.15	.24
	WA	6.83	.23
French Fries- Oven Type			
	MI	7.20 - 7.65	.24 - .26
	ME	6.90 - 7.15	.23 - .24
	WA	6.11 - 7.14	.20 - .24

SOURCE: Agricultural Marketing Service, USDA, 1985.

money into consideration and it allows incorporation of time lags between initial investment and operation of the plant at full capacity.

The analysis was done under three basic scenarios--A, B, and C. Scenario A, used an IRR based on the net margin estimated in the previous section. Net margins were based on PNW origin product prices. In scenario B, a conservative $.01/pound was added to the margin to reflect the locational advantage that a North Dakota plant would have over the PNW in serving the major Midwest and Eastern markets. Michigan, Minnesota, and Maine have received price premiums in the range of $.02-.06 when bidding for frozen potato contracts through the Agricultural Marketing Service. Scenario C was based on the same margins as in scenario B, except that plant utilization was assumed

TABLE 30. FROZEN POTATO PRICES, ACCEPTED BID, AGRICULTURAL MARKETING SERVICE, 1986

Award Date Product	Shipping Point	Price/Case		Price/pound	
		- - - - - -	dollars	- - - - - -	
March 6, 1986					
French Fries- Fry Type					
	ME	6.30		.21	
	MI	7.05		.24	
	ID	6.30		.21	
French Fries- Oven Type					
	MI	6.59	6.90	.22	.23
	ME	6.30	6.85	.21	.23
	WA	5.77	5.84	.19	.19
	ID	5.66		.19	
	OR	5.91		.20	
Potato, Rounds, Frozen					
	ME	8.10	8.40	.27	.28
	MI	7.94		.26	
	WI	7.94		.26	
	ID	7.05	7.17	.24	.24
	WA	6.87		.23	
December 19, 1986					
French Fries- Fry Type					
	ME	6.88		.23	
	WA	5.97		.20	
French Fries- Oven Type					
	ME	6.88	7.20	.23	.24
	MI	7.50		.25	
	WA	5.97	6.51	.20	.22
	ID	6.45		.22	
	MN	7.50		.25	
Potato, Rounds, Frozen					
	ME	8.25	8.38	.28	.28
	OR	6.74	7.27	.22	.24
	ID	5.99	7.27	.20	.24
	WA	6.72		.22	

SOURCE: Agricultural Marketing Service, USDA, 1986.

TABLE 31. FROZEN POTATO PRICES, ACCEPTED BID, AGRICULTURAL MARKETING SERVICE, 1987

Award Date Product	Shipping Point	Price/Case		Price/pound	
		------	dollars	------	
March 9, 1987					
French Fries- Fry Type					
	ID	6.75		.23	
	WA	6.29		.21	
French Fries- Oven Type					
	ME	6.69	7.14	.22	.24
	MI	7.80	7.95	.26	.27
	WA	6.14	6.34	.20	.21
	ID	6.53	6.75	.22	.23
Potato, Rounds, Frozen					
	ME	7.89		.26	
	OR	6.29		.21	
	ID	6.29	6.75	.21	.23
	WA	6.78		.23	

SOURCE: Agricultural Marketing Service, USDA, 1987

to be 50 percent the first year and increasing by 10 percent annually until reaching full capacity.

The estimated IRR for the plant operating under the first scenario ranges from 28.9 percent under the high margin estimate to 11.6 percent for the low margin estimate. The midpoint estimate yielded an IRR estimate of 20.7 percent. Adjusting the margins to reflect a transportation advantage increases IRR estimate to 33 percent for the high margin estimate, 24.9 percent for the midpoint estimate, and 16.3 percent for the low point estimate. Under the less than full plant utilization scenario, the IRR estimates drop to 24.6, 18.9, and 12.4 percent for the high, midpoint, and low margin estimate (Table 33).

In summary, given that margin estimates, processing costs, and a planning horizon of 15 years are conservatively estimated, frozen potato processing in North Dakota yields consistently profitable results. This is true even under the assumption that plant utilization levels do not reach full capacity until the sixth year of operation.

TABLE 32. ESTIMATED FROZEN POTATO PROCESSING MARGINS, NORTH DAKOTA BASED PLANT, 1988

	Low	Midpoint	High
		$/lb.	
Baseline	.155	.175	.195
Transportation premium	.165	.185	.205

North Dakota's Competitive Position

This section analyzes the competitive position of a North Dakota based frozen potato processing plant with respect to other processing areas in the United States. In order for additional North Dakota processing plants to be economically viable, these plants must be able to competitively deliver enough product to consumption areas to maintain full plant utilization. The analysis will identify, through a linear programming model, least-cost market areas and least-cost product movements from processor to consumption markets.

There are three sections to the analysis. The first section will identify the least-cost distribution patterns incorporating only transportation costs. The second analysis will incorporate differential processing

TABLE 33. ESTIMATED INTERNAL RATES OF RETURN FOR NORTH DAKOTA BASED FROZEN POTATO PROCESSING PLANT, 1988

	Margin Estimates		
	Low	Midpoint	High
		percent	
Scenario A	11.6	20.7	28.9
Scenario B	16.3	24.9	33.0
Scenario C	12.4	18.9	24.6

costs in addition to transportation costs. The third section addresses the location of a new plant by an existing firm in the industry. The linear programming model will determine which new plant location will maximize a firm's net revenue by minimizing total raw product costs, processing costs, and transportation costs.

Industry Characteristics

Frozen potato processing is concentrated in the PNW. Idaho, Washington, and Oregon are the major processing states in this region. Major processing plants are also located in North Dakota, Minnesota, Wisconsin, Michigan, and Maine (Figure 15). The PNW has accounted for over 80 percent of all potato processing (frozen and dehydrated) from 1983 to 1986 crop years. USDA does not differentiate between dehydrated and frozen potato processing in its reporting. Four states including North Dakota, Minnesota, Wisconsin, and Michigan account for approximately 15 percent with Maine accounting for approximately 5 percent of processing capacity (Table 34). North Dakota, Minnesota, Wisconsin, and Michigan are characterized by having one major potato processor.

The domination by the PNW in potato processing has been attributed to several factors. These include low potato prices, low processing costs, and productive land (Buteau, 1986; Zink, 1980). Frozen potato processing and dehydration are very energy intensive. Inexpensive electricity in the PNW serves to greatly lower processing cost giving that area a comparative input cost advantage. Low electric costs are attributed to the availability of hydroelectric generation in the PNW.

Weight reduction of processed potato products also encouraged the more distant production area to specialize in processing to minimize transportation costs while production areas near population centers supply fresh potatoes.

Model parameters are six supply points, 48 destinations or demand points, total market demand of 5,500 million pounds, and truck and/or rail transportation modes. The six supply points are Washington/Oregon, Idaho, North Dakota/Minnesota, Wisconsin, Michigan, and Maine. Washington and Oregon are represented as one supply point as are Minnesota and North Dakota. Due to the proximity of production areas and the likelihood a product produced in one state may be processed in another, called for combining these states. Forty-eight demand points were selected with the largest metropolitan area representing each state. California, Florida, Texas, and New York had multiple destination points. Smaller states in the Northeast were grouped together. Total market demand is based on estimated U.S. domestic consumption of frozen potato products in 1990. Both rail and truck shipments were included in the model. Rail shipments to each destination point were limited to 50 percent of total shipments to that demand point. It was estimated by several industry sources that rail accounts for approximately one-third of all shipments, and the remaining two-thirds moves by truck. Rail has a transportation cost advantage over trucking when distances are generally greater than 200 to 300 miles; however, rail transportation has several cost and noncost considerations.

Added rail costs include longer delivery times, potentially higher inventory costs, and greater handling costs. Noncost considerations include less control over shipping once shipment occurs, potential car scheduling problems, no emergency shipping options, and more restrictive planning horizons. Longer delivery times result in greater capital requirements for either seller or buyer. Rail cars have a higher payload, 80,000-95,000 pounds versus 43,000-46,000 for trucks, thus greater inventory equipment and additional storage cost for the end user. Additional

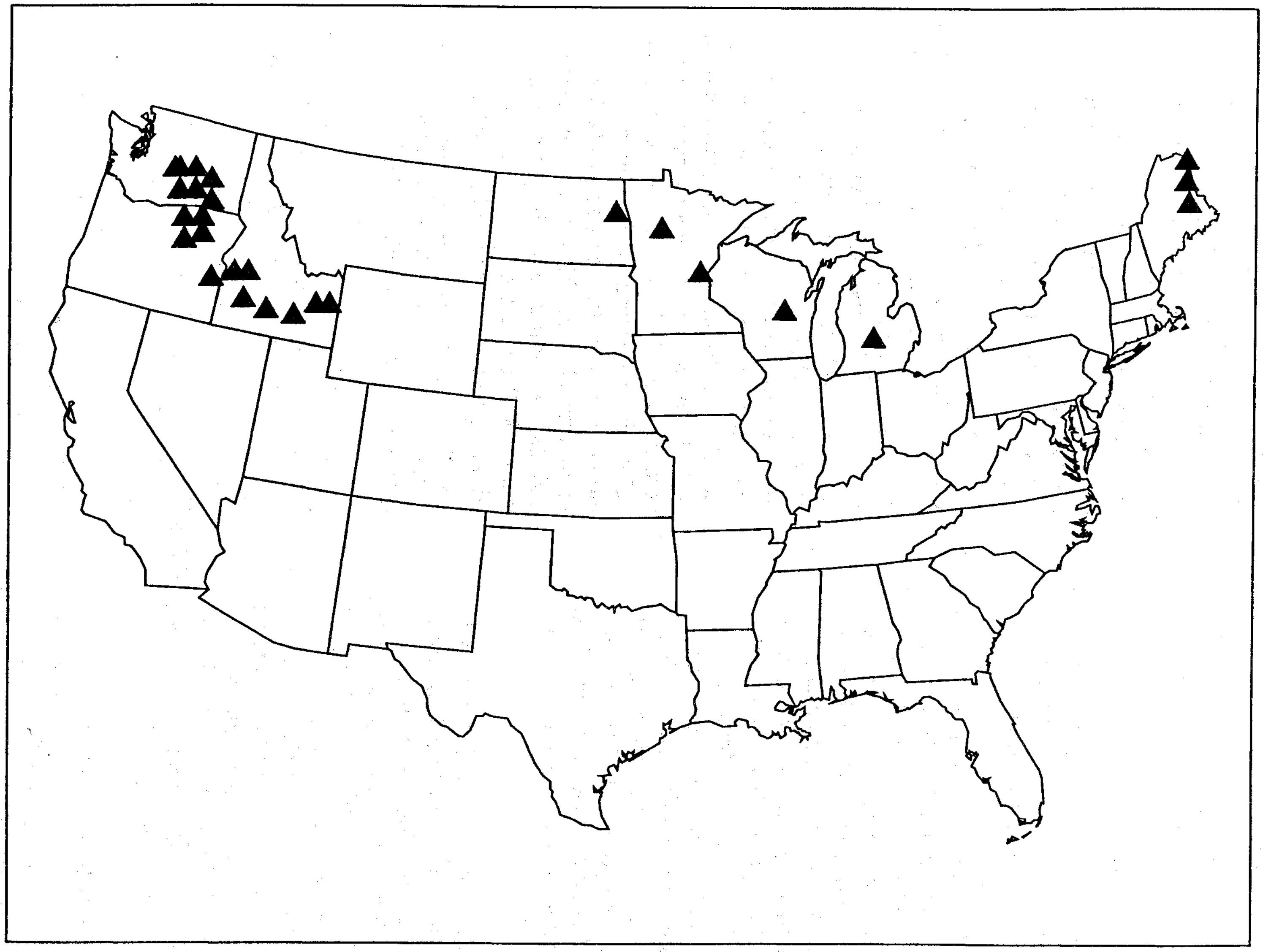

Figure 15. Major Frozen Potato Plant Locations

SOURCE: Northwest Food Processors Association, 1988; Bateau, 1986; and other Industry Sources.

TABLE 34. POTATOES USED FOR PROCESSING, FROZEN AND DEHYDRATED, EIGHT STATES, 1983-1986[1]

State	1983-84	1984-85	1985-86	1986-87
	1,000 cwt.			
Idaho and Malheaur Co. Oregon	53,810	57,410	55,220	55,470
Washington and other Oregon	45,800	51,670	57,430	56,910
Maine[2]	5,125	6,550	8,660	6,995
Other States[3]	16,320	21,005	22,245	20,975
Total	121,055	136,635	143,555	140,350

[1]Total quantity received and used for processing regardless of the state in which the potatoes were produced. Does not include quantities used for potato chips in Maine, Michigan, Minnesota, North Dakota, or Wisconsin.
[2]Includes Maine grown potatoes only.
[3]Michigan, Minnesota, North Dakota, and Wisconsin.

SOURCE: Potato stocks, Agricultural Statistics Board, Various Issues.

storage cost may include public warehousing costs. Greater handling costs are incurred in the unloading by the buyer given the buyer is responsible for unloading the rail car while the truck driver will assist in the unloading of a semi-trailer. Unloading times are greater for rail cars running 4-5 hours versus 1/2 hour for trucks even though the payload is only twice as large. Pallet exchanges are possible with truckers.

Other nondirect cost considerations are a greater possibility of rail cars being delayed or sent to wrong locations, especially if several line switches are involved. Emergency or overnight shipments are not possible with rail. Rail delivery may require additional transfer and handling costs if public warehousing is not available or not conveniently located for an end user. A longer planning horizon is also required for rail versus truck as rail cars have a longer turnaround time.

Least-cost Product Movement - Transportation Costs Only

Transportation rates are based on a sample of actual rates. Rail rates were estimated by the following formula:

$$\text{Rate} = 393.80 + 1.844 \text{ miles}$$

where: Rate = cost, dollars per rail car

Mile = road miles

Truck rates were estimated by the following formula:

$$\text{Rate} = 100 + 1.25 \text{ miles}$$

where: Rate = cost, dollars per truck

Mile = road miles

The rail rate formula was estimated by linear regression based on a sample of actual rates. The R^2 for the rail rate equation was .96. The truck rate was estimated after consultation with the trucking industry personnel. Truck rates from the PNW were reduced by $.10/mile, the lower rate was attributable to a higher degree of competition for truck movement originating in the PNW. The resulting break-even point between rail and truck was 300 miles, with rail having a rate advantage on the longer hauls.

Least-cost product flows incorporating only transportation costs are depicted in Figure 16. Maine has a cost advantage in serving the Northeast markets. Michigan has a cost advantage in serving the mid-Atlantic, Eastcentral, and Southeast states. Wisconsin has a cost advantage in only serving neighboring states. North Dakota/Minnesota is the least-cost shipper for states between North Dakota and Texas. Idaho serves most of the Western states with Washington and Oregon serving the extreme Northwest.

Assuming an average consumption of 22.5 pounds (45-pound fresh equivalent) of frozen potatoes annually, Michigan has the largest least-cost market area of 2,752 million pounds. Idaho follows with 936 million, Maine with 784 million, North Dakota with 467 million, Wisconsin with 383 million, and Washington and Oregon with 164 million pounds (Table 35).

Least-cost Product Movement Incorporating Differential Processing Costs and Transportation Costs

Transportation costs are only one of the factors in determining least-cost product movement. In this section regional differences in processing costs are incorporated into the analysis. The four major processing costs that vary regionally are electricity, natural gas, labor, and raw product costs. Incorporating regional price differentials with resource requirements provided previously, regional cost differentials were established. The processing cost differentials and transportation rates were used to develop least-cost product flows.

Electricity cost is the lowest in Washington and Idaho, only 2.33 and 2.54 cents per kilowatt. Only Michigan exceeds North Dakota in electrical cost. The PNW and Wisconsin have lower electrical rates because of the larger supply of hydro-electric generating capacity in those states. The variation in natural gas cost is less than that of electricity with North Dakota having the lowest cost. Michigan is the high-cost labor state followed by Washington and Wisconsin. Average labor rates for the food and kindred industry were 10.77, 9.60, and 9.50 dollars per hour, respectively (Table 36). Maine had the lowest cost of labor at 7.18 dollars per hour. Price differentials for the potato raw product were more difficult to estimate. Although all regions selected are major fall producing areas, there is a wide differential in varieties grown between regions. Washington and Idaho grow Russet Burbanks almost exclusively for processing while other states such as Michigan, North Dakota, and Wisconsin grow several different varieties for their respective frozen, chipping, and fresh potato markets.

Average farm price received by farmers for fall potatoes was used. The authors are aware that depending on market conditions price for processing potatoes may differ from the overall average. However, if price differentials are too great, producers will shift between markets, thus minimizing potential differentials. Also, price differentials between states are narrowing between regions (see page 6).

Resource costs and net processing cost differentials are presented in Table 36. Three states, Maine, Michigan, and Wisconsin, have higher processing costs than

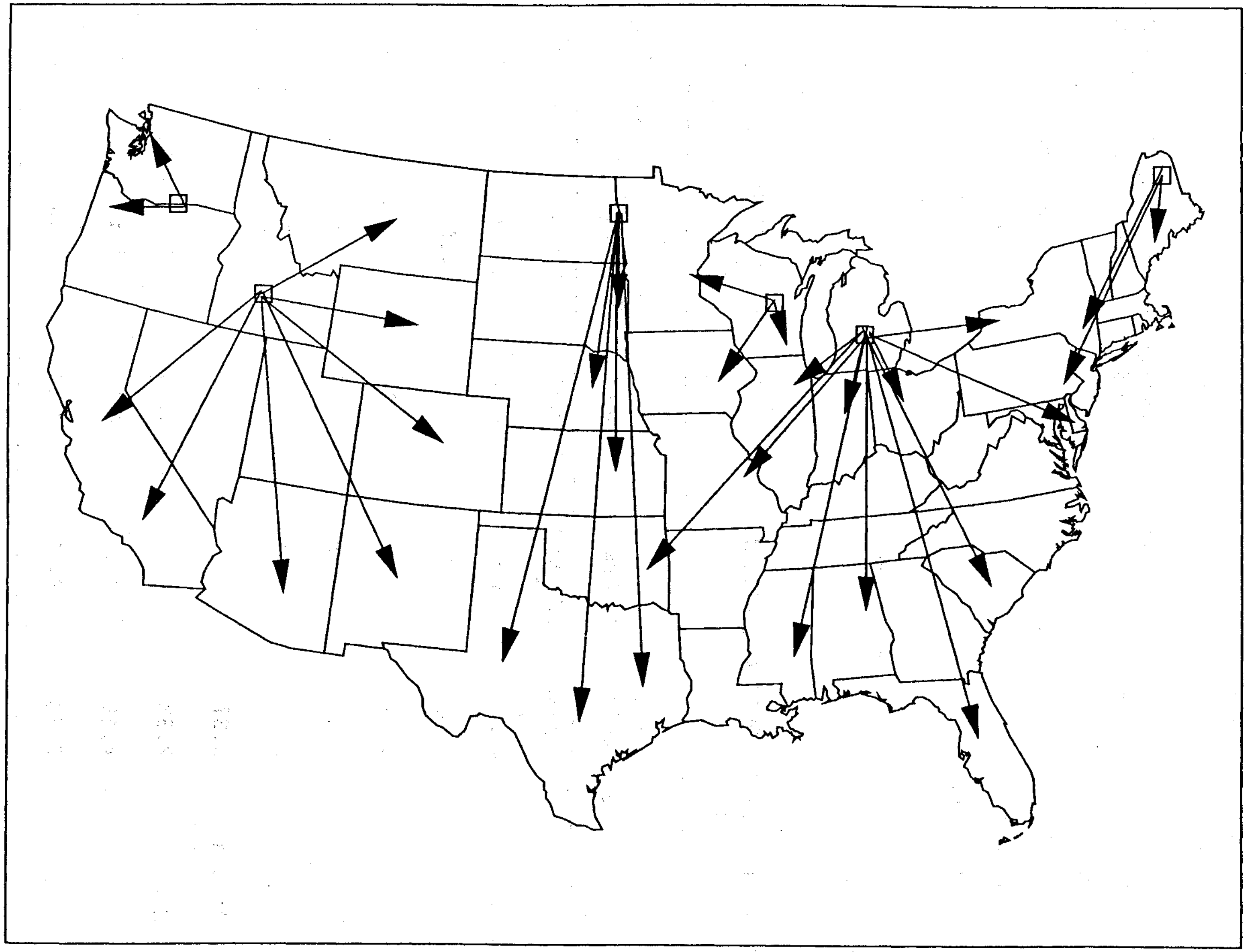

Figure 16. Least-Cost Transportation Costs for Processed Potato Products, Product Movements - Transportation Costs Only, 1988.

TABLE 35. LEAST-COST MARKET AREA'S SIZE BY PROCESSING LOCATION, TRANSPORTATION COSTS ONLY, 1988

Processing Location	Market Size
	(000 pounds)
Washington/Oregon	164,000
Idaho	936,000
North Dakota/Minnesota	467,000
Wisconsin	383,000
Michigan	2,752,000
Maine	784,000

TABLE 36. RESOURCE COSTS AND REGIONAL PROCESSING COST DIFFERENTIALS BY STATE, 1988

	Electric[1]	N. Gas[1]	Labor[2]	Potatoes[3]	Net Change Pro. Costs
	cents/kwh	$/MM btu	$/hour	$/cwt	$/1000 #
Colorado	4.28	3.93	8.16	4.08	-6.40
Idaho	2.54	4.33	8.16	4.24	-6.47
Maine	4.78	6.14	7.18	4.34	1.15
Michigan	5.51	4.78	10.77	5.41	30.72
Minnesota	4.28	4.03	8.76	4.55	1.22
North Dakota	5.37	4.29	8.13	4.25	.00
Washington	2.33	4.59	9.60	4.16	-4.60
Wisconsin	4.19	4.46	9.50	4.46	5.13
Oregon	3.34	4.63	8.64	4.26	-2.60

[1]Department of Energy, 1985.
[2]Bureau of Labor Statistics, 1988.
[3]Adapted from Table 10.

North Dakota. Processing cost differentials for Maine, Michigan, and Wisconsin relative to North Dakota are 0.11, 3.1, and 0.5 cents more per pound of finished product. Idaho has the lowest cost, 0.64 cents per pound lower than North Dakota. Washington is .46 cents per pound lower and Oregon .21 cents per pound lower than North Dakota.

Inclusion of differential processing costs had major impacts on least-cost product flows. Michigan no longer had a cost advantage in any market, including its own state, because Wisconsin processors had a lower cost than Michigan processors in serving Michigan. Wisconsin was the primary beneficiary, increasing its least-cost market area from 383 million pounds to 2,097 million pounds. North Dakota/ Minnesota increased from 467 million to 705 million pounds and Maine from 784 to 1,508 million pounds (Figure 17 and Table 37). The PNW had marginal increases. In recent years Ore-Ida, a major frozen potato processor, discontinued processing in Michigan. This analysis is consistent with that decision by Ore-Ida.

Compared to actual regional processing volumes (Table 34) some inconsistencies exist. Primarily, Wisconsin and Maine do not process the volume of potatoes that the least-cost transportation analysis would suggest. Also, Michigan still processes potatoes. Reasons for this are several. First, the model only identifies least-cost movement based on current data. Data for the analysis are current data (transportation rates, processing costs, and raw product costs). The establishment of the frozen potato industry was a result of prior decisions based on current data at that time. In the 1970s the PNW incurred relatively lower raw product prices and lower electrical costs than they do now. In 1970, electrical costs for the industrial section in North Dakota was $5.96/million btu, Washington's cost was only $.97/million Btu (Table 38). In 1985, North Dakota cost was $15.94/million Btu and Washington's was $6.45/million Btu. Relatively, the cost advantage that Washington has (PNW in general) is decreasing over time. Washington's costs were only 17 percent of North Dakota's costs in 1970 and by 1985 it had increased to 40 percent. The model determines optional least-cost product flows based on current data, thus the model indicates that industry costs could be reduced if processing is moved eastward. The primary factor being that transportation savings resulting from processing being relocated to states such as North Dakota, Maine, and Wisconsin exceed the increased costs due to increased processing costs and higher potato prices.

Expanded production in Wisconsin and Maine; however, is limited. The production of potatoes in Wisconsin is concentrated in the Central Sands area; Stevens Point is the leading city in the area (Grieg, 1978). This area also relies on irrigation and recently is incurring some groundwater contamination due to intensified crop production in this area. W. Smith Grieg, 1976, estimated the increased production in the Central Sands area would be limited to 30,000 acres. Some of this expansion has already occurred. Maine, however, has been affected by production problems. Maine is the only fall potato producing state that has not increased yields. Maine has incurred significant reduction in potato production throughout the 1970s and 1980s. Potato production areas in Maine are characterized as small farms that have not been able to benefit from recent technological advances due to constraints on size of farming units. Disease problems have also contributed to a decline in production. In light of declining production, it is unlikely that frozen potato processing would expand significantly.

Michigan, although at a significant cost disadvantage, is still likely to continue

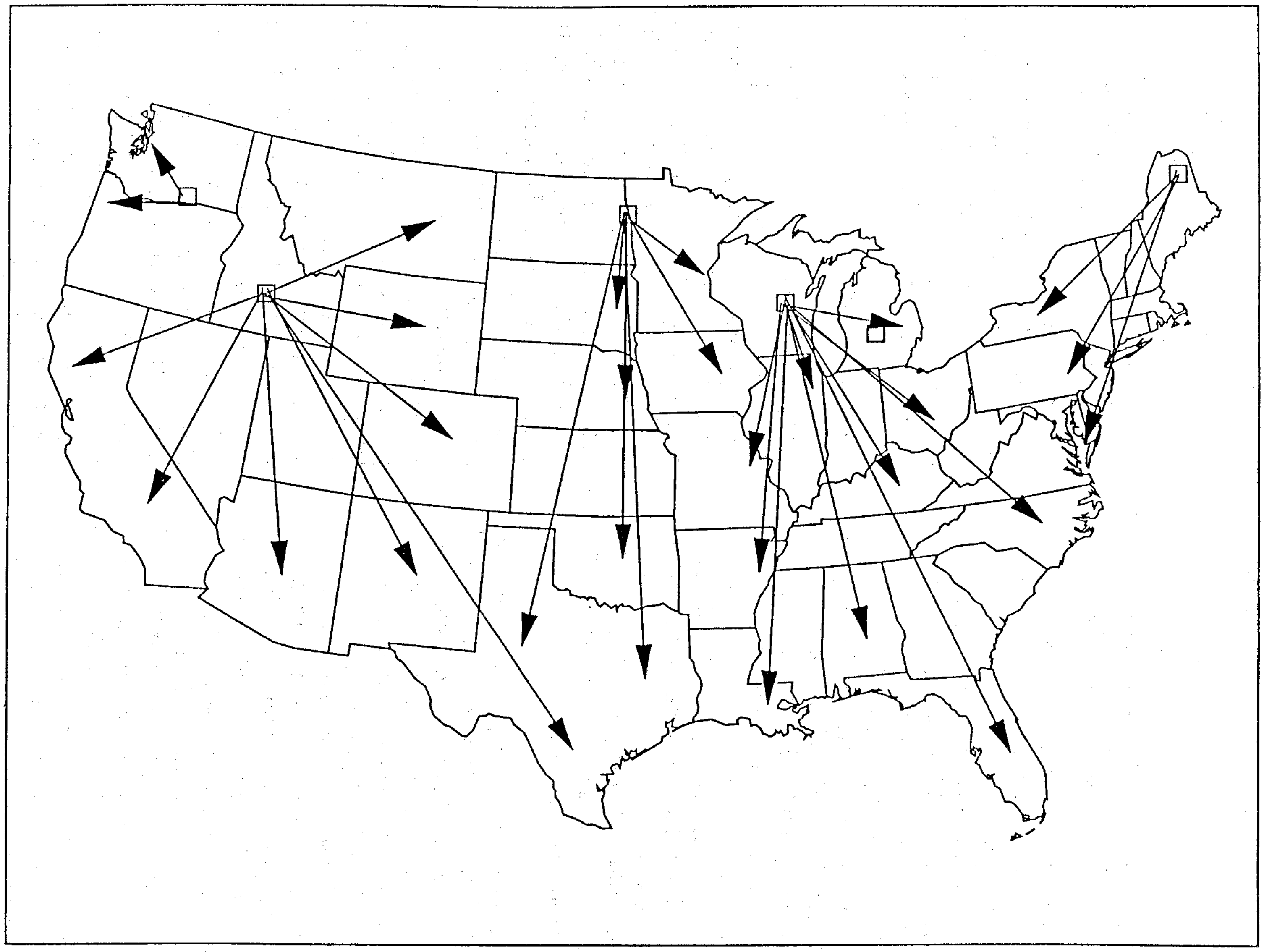

Figure 17. Least-Cost Product Flows, Incorporating Transportation Costs and Processing Cost Differentials, 1988.

TABLE 37. LEAST-COST MARKET AREA'S SIZE BY PROCESSING LOCATION, BASED ON TRANSPORTATION AND DIFFERENTIAL PROCESSING COSTS, 1988

Processing Location	Market Size
	(000 pounds)
Washington/Oregon	164,000
Idaho	1,013,000
North Dakota/Minnesota	705,000
Wisconsin	2,097,000
Michigan	0
Maine	1,508,000

TABLE 38. ELECTRICAL COSTS[1]; NORTH DAKOTA AND MAJOR PACIFIC NORTHWEST STATES, AND UNITED STATES AVERAGE, 1970, 1975, 1980, AND 1985

Year	North Dakota	Idaho	Oregon	Washington	United States
	- - - - - - - - - - - -		$/million btu	- - - - - - - - - -	
1970	5.96	1.85	1.26	.97	2.99
1975	8.03	2.69	2.15	1.36	6.07
1980	9.99	5.47	4.68	2.26	10.81
1985	15.94	8.01	10.77	6.45	15.12

[1]Industrial Sector.

SOURCE: Department of Energy, 1985.

processing frozen potatoes. Firm decision making criteria differs between discontinuing plans to expand and closure of existing plants. Once a plant is built, fixed costs are already incurred and thus are no longer considered in the decision to discontinue processing. Also, existing plants may also have lower fixed costs due to lower construction cost.

The model was adjusted for these market conditions. Maine processing was limited to 5 percent of total market demand, which was consistent with historical processing levels. Due to existing plants, Michigan, Wisconsin, and North Dakota processing was constrained so that each state processes at a minimum level of 4 percent of the market. Wisconsin processing was limited to 6 percent of market demand. North Dakota and Minnesota movements have usually been by truck, thus two scenarios were analyzed. Scenario A: North Dakota/Minnesota utilized both rail and truck movements. Scenario B: North Dakota movements limited to truck only.

Results are presented in Table 39. North Dakota's least-cost market substantially increases under both scenarios, increasing to 3,500 and 2,000 million pounds, respectively. North Dakota is the primary benefactor from the processing constraints placed on Wisconsin and Maine. Least-cost market areas are depicted in Figure 18 for scenario B.

Site Location Analysis

The frozen potato industry is growing. By the year 2000 the potato industry is expected to increase by 20 percent assuming current trends continue. This estimated expansion provides opportunities for firms interested in expanding production. Even if a firm is not interested in increasing its market share, the firm must increase production to maintain current market share. This section analyzes which plant location minimizes total firm processing and transportation costs in serving its market.

Assumptions are the firm has an existing market share of approximately 15 percent or 825 million pounds of frozen potato products. It plans to build a new plant and expand processing by 325 million pounds annually. Current processing plants are located in Idaho and the Washington/Oregon area, with annual processing equally split between the two locations. The plant markets its product nationally and desires to have equal market penetration in all areas. The firm utilizes both rail and truck movements, and rail movements are limited to 50 percent of the demand at each demand point.

Four different plant locations are considered. These are Washington/Oregon, Idaho, North Dakota, and Colorado. Colorado is included because it is the only major fall producing potato state that does not have any frozen potato processing. Maine is not considered because of its declining production and Michigan is not considered because of high processing costs in that state. Wisconsin is not considered because of potential limitations to expand potato production.

Results of the linear programming model indicate that a North Dakota/Minnesota or a Colorado plant site location would be optimal in minimizing total processing, raw product, and transportation costs. Total firm cost (all costs combined) was $313.5 million for North Dakota/Minnesota, $331.0, $320.9, and $317.9 for Colorado, Washington/Oregon, and Idaho, respectively (Table 40). The Colorado location was similar to North Dakota/Minnesota in total cost. By locating in North Dakota/Minnesota the firm would realize annual savings of $7.4 and $4.3 million compared to locating the new plant in Washington/Oregon and Idaho, respectively. These cost savings are

TABLE 39. LEAST-COST MARKET AREA'S SIZE BY PROCESSING LOCATION INCORPORATING TRANSPORTATION COSTS, DIFFERENTIAL PROCESSING COSTS, AND PROCESSING CONTSTRAINTS

Processing Location	Market Size: Scenario A[1]	Market Size: Scenario B[2]
	- - - - (000 pounds)	- - - -
Washington/Oregon	164,000	164,000
Idaho	1,013,000	1,888,000
North Dakota/Minnesota	3,485,000	2,610,000
Wisconsin	220,000	220,000
Michigan	220,000	220,000
Maine	385,000	385,000

[1]North Dakota movements, truck and rail.
[2]North Dakota movements limited to truck only.

substantial when compared to the required investment of $63.5 million for a new plant.Idaho, respectively.

The North Dakota/Minnesota cost advantage is a result of transportation cost savings. Actual processing and raw product costs are higher relative to the PNW. An example is expansion in Idaho would result in $2 million savings in processing but this would be more than offset by the additional transportation costs of $6.4 million.

The firm's optimal transportation pattern if North Dakota/Minnesota was the new plant location are depicted in Figures 19 and 20. Truck movements are shown in Figure 19 and rail movements in Figure 20. The North Dakota/Minnesota plant was used exclusively for truck movements to the Midwest, Northeast, and mid-Atlantic states. The Idaho location supplied the truck shipments to the South and the Washington location to the Northwest. Rail movements to the northern half of the United States originated in Washington with Idaho being the origin for rail movements to the southern half of the United States.

Economic Impact

The economic impacts resulting from the construction and operation of a frozen potato processing plant in North Dakota can be measured in terms of several key economic variables. Numerous direct, indirect, and induced impacts would occur within the state. These include increased levels of business activity, retail sales, and personal income. Additional tax revenue would also be generated.

The analysis was based on the plant operating 240 processing days per year. All impacts will be reported as occurring in North Dakota since a specific location

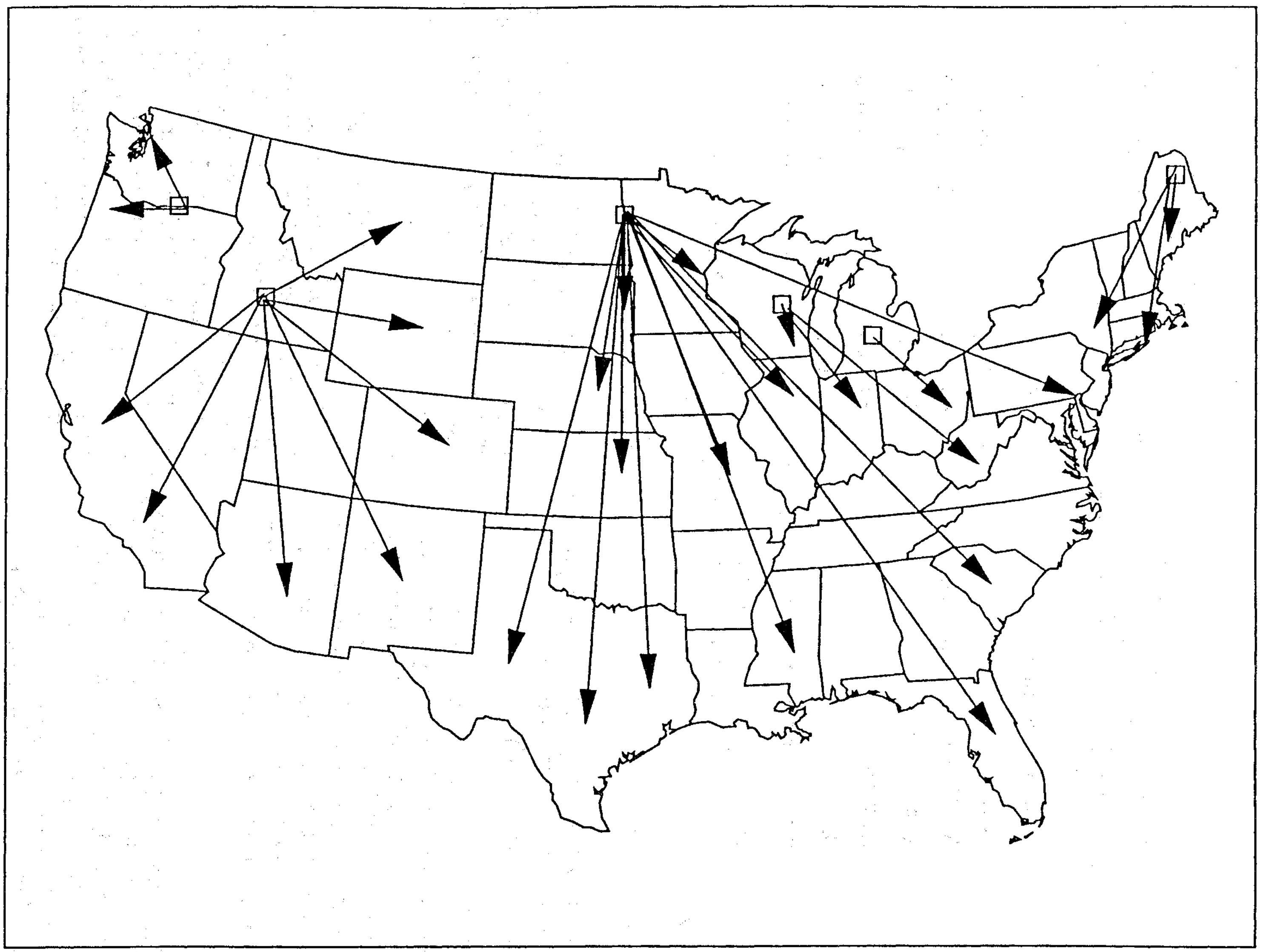

Figure 18. Least-Cost Product Flows with Processing Constraints, 1988.

TABLE 40. HYPOTHETICAL FIRM PROCESSING AND TRANSPORTATION COSTS FOR NEW PLANT LOCATION, UNITED STATES, 1988

Location	Costs			
	Processing	Raw Product	Transportation	Total
	$000			
Washington/Oregon	171,271	94,451	55,216	320,938
Idaho	170,153	94,961	52,738	317,852
North Dakota	172,192	95,025	46,327	313,544
Colorado	171,196	93,941	47,861	312,998

was not specified. Both construction and operational impacts will be analyzed. The construction impact refers to the "one time" business activity generated as a result of the construction of the facility. Economic impacts from the operation of the plant would result each year the plant was in operation. These impacts are annually recurring, but were determined for one year based on the expected annual expenditures that would result from a processing plant operation. Economic impact results are reported in 1987 dollars.

Local Expenditures

Local expenditures during the construction phase totaled $24.8 million. Direct construction expenditures were $18.2 million, retail sector $5.5 million, and real estate $1.1 million (Table 41). It was assumed that building and miscellaneous capital expenditures were in-state expenditures as well as 15 percent of equipment costs.

Expenditures during the operational phase were distributed among six sectors of the state economy. The household sector received the largest expenditures ($7.9 million) followed by the public utility sector with over $6.5 million. The household sector represents wage and salaries from operation of the plant. One-half of the general and administrative expenses were assessed to be in-state expenditures and were allocated between the household, business, and professional sectors. Packaging expenditures were assumed out-of-state.

Total Business Activity

Applying construction and operational phase expenditures to the multipliers provided estimates of personal income, retail trade, and total business sector activity (Coon 1986). Retail trade associated with the construction of the plant totaled $15.2 million and $12.4 million in annual retail trade activity associated with plant operations.

Personal income attributable to construction of the plant was estimated at $14.6 million. Operations generated annual personal income of $21.0 million. Total business activity associated with

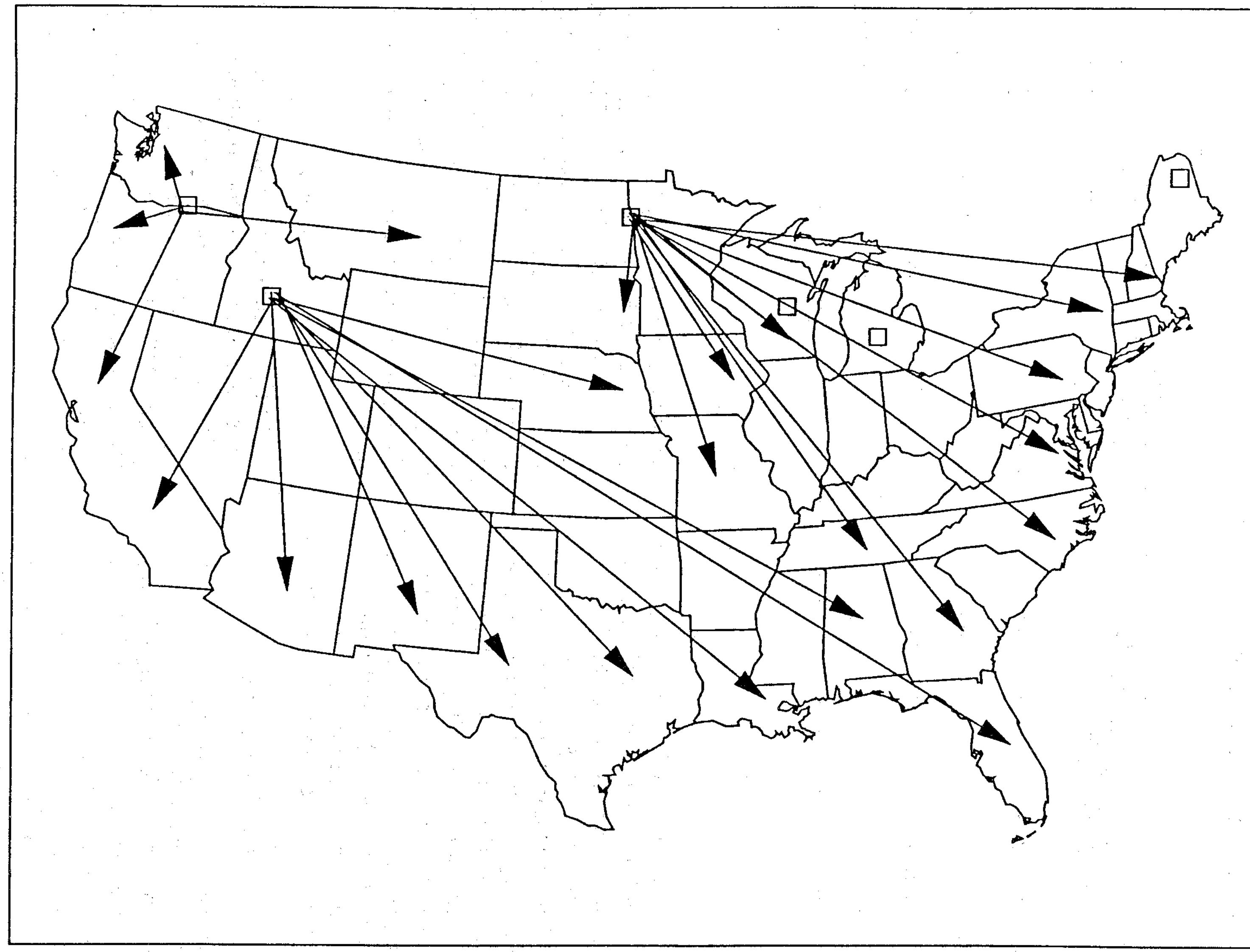

Figure 19. Hypothetical Firm's Least-Cost Truck Shipments, 1988.

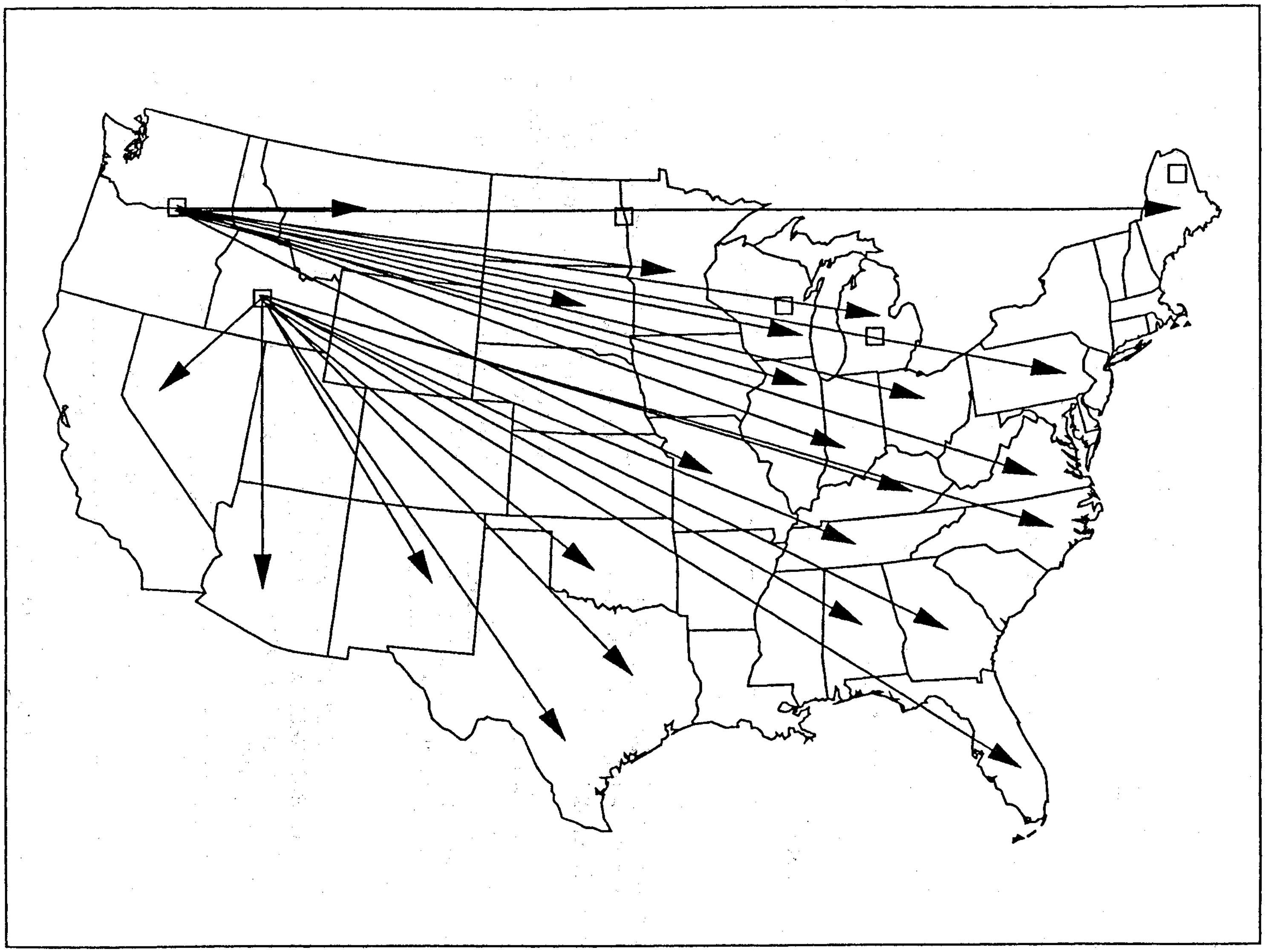

Figure 20. Hypothetical Firm's Least-Cost Rail Shipments, 1988.

TABLE 41. ESTIMATED LOCAL CONSTRUCTION AND OPERATION PHASE EXPENDITURES FOR MODEL FROZEN POTATO PROCESSING PLANT, NORTH DAKOTA, 1988.

	Item	
	Construction	Operation
	--- thousand dollars ---	
Construction	18,200	--
Transportation	--	--
Commercial and public utilities	--	6,542
Retail	5,500	1,492
Fire	1,075	1,250
Business and personal services	--	782
Professional and social services	--	782
Households	--	7,964
Total	24,825	18,812

construction of the facility was $59.9 million and $55.3 million annually from operations (Table 42).

Tax Collections

Estimated total tax revenues resulting from the construction and operation of the plant are presented in Table 43. Construction generated $810,000 in sales tax, $319,000 in North Dakota personal income tax, and $147,000 in North Dakota corporate income tax. Operations generated $988,000 of sales tax, $652,000 in North Dakota income tax, and $197,000 in North Dakota corporate income tax annually.

TABLE 42. ESTIMATED PERSONAL INCOME, RETAIL TRADE ACTIVITY, AND TOTAL BUSINESS ACTIVITY RESULTING FROM THE CONSTRUCTION AND OPERATION OF THE MODEL FROZEN POTATO PROCESSING PLANT, NORTH DAKOTA, 1988

Item	Personal Income	Retail Sales	Total Business Activity
	------- thousand dollars -------		
Construction phase	14,593	15,193	59,895
Operational phase	21,045	12,376	55,255

TABLE 43. ESTIMATED TAX REVENUES FROM CONSTRUCTION AND OPERATION OF THE MODEL FROZEN POTATO PROCESSING PLANT, NORTH DAKOTA, 1988

Item	Sales Tax	Personal Income Tax	Corporate Income Tax
	- - - - - - thousand dollars - - - - -		
Construction phase	810	319	147
Operational phase	988	652	197

Summary and Conclusions

The primary objective of the study was to determine the overall economic feasibility of expanded potato processing in North Dakota. Specifically, three questions were answered: 1) Which processed product form has sufficient market potential to provide an opportunity for expanded processing in North Dakota? 2) Are processing margins sufficient to return an adequate return on investment to attract potential investors? 3) Is a North Dakota processing location competitive with other established processing areas in supplying major U.S. markets?

The processing of potatoes into frozen potato products, french fries, hash browns, etc., was found to be the most feasible after analyzing consumption trends. Overall potato consumption from 1970 to 1986 was relatively constant, averaging 118.9 pounds per capita. Market share for fresh, canned, and dehydrated product decreased during this time period. Although canned and dehydrated product share has stabilized, fresh consumption continues to decrease.

Consumption of chips has remained relatively constant. Frozen potatoes were the only product to show increased market share. Frozen potato market share increased to 33.4 percent during 1980-1984 from only 26 percent during 1970-1974. Market share is expected to increase to 38 percent by 1990. The rapid shift from fresh to frozen product is slowing resulting in a slower, but still increasing per capita consumption of frozen potato products. However, total U.S. demand for frozen potato products is still increasing significantly due to a growing population base. Average domestic consumption was 90.5 million cwt. (fresh weight equivalent) during 1980-1984 compared to 64 million cwt. during 1970-1974. Consumption is expected to increase by 15.5 percent to 114.5 million cwt. during the 1990-1994 time period. Population growth will partially offset the per capita decline in the dehydrated industry, but most likely will not increase above levels experienced during the 1970s. Likewise, population growth will offset the per capita decline in fresh consumption, but net growth will be marginal. The chipping industry will experience future growth. However, the chipping industry is primarily a consumption-based industry. Since North Dakota and nearby states are not densely populated, it is unlikely that processing of potato chips on a large scale would be feasible in North Dakota.

Based on market analysis, frozen potato processing was identified as the only form of large-scale processing that would be viable in a North Dakota location.

Economic profitability was based on estimated processing costs of $15.3/cwt. of finished product and processing margins of $15.5, $17.5, and $19.5/cwt. of finished product excluding raw product costs.

Internal rates of return were estimated at 11.6, 20.7, and 28.9 percent for the low, midpoint, and high margin estimates. Increasing margin by $1/cwt. to reflect transportation savings for a North Dakota location increases internal rates of return to 16.3, 24.9, and 33 percent for the low, midpoint, and high margin estimates. Under the assumption that full-plant utilization would not be reached until year five, the internal rates of return remained attractive at 12.4, 18.9, and 24.6 percent for the low, midpoint, and high margin estimates. Given that margins and processing costs were conservatively estimated, frozen potato processing in North Dakota yields consistently profitable results. The transportation analysis incorporating transportation rates and regional processing costs indicate that the North Dakota/ Minnesota region has a least-cost market that greatly exceeds existing regional production. The reduction in transportation cost was the primary factor as the PNW has lower processing cost due to less-expensive electricity; however, transportation savings exceed any increase in processing cost.

The processing cost advantage enjoyed by the PNW is gradually eroding as the differential between North Dakota and the PNW electrical cost narrow.

Results from the transportation analysis indicate that an existing firm located in the PNW could greatly reduce total processing and transportation cost if expansion was in North Dakota relative to expansion in Washington, Oregon, or Idaho.

Economic impact of a frozen potato processing plant in North Dakota was also investigated. The processing plant would generate additional local expenditures of $18.9 million in the local community. These local expenditures would in turn generate over $50 million in overall business activity.

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